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ABSTRACT

This solar energy curriculum guide is designed to assist teachers in infusing energy concepts into vocational education programs. It consists of 31 competency-based instructional units organized into 10 sections. Covered in the sections are the following topics: related instructions (history and development; human relations; general safety; building, plumbing, and electrical codes; and applying for a job); electricity (fundamentals of electricity, electric power, and electric test instruments); electric motors and contacts (introduction to electric motors, split-phase motors, and capacitor motors); tools and equipment (basic hand tools, solar technician's tool box, special tools, power tools, and equipment); soldering, cutting, and welding; piping (pipe, pipe fittings, and joining pipe); blueprint reading; solar hot water systems (components and system installation); safety in air conditioning; and heating and cooling (special tools, solar assisted heat pumps, and solar absorption systems). Each unit contains the following: a performance objective, suggested activities for instructors and for students, information sheets, transparency masters, assignment sheets, job sheets, criterion-referenced tests, and test answers. (MN)

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A MODEL FOR INFUSING ENERGY CONCEPTS INTO VOCATIONAL EDUCATION PROGRAMS

SOLAR ENERGY CURRICULUM GUIDE

Project Number: E3176

Conducted By
Delta Vocational Technical School
Marked Tree, Arkansas 72365
Robert Watson Jr., Project Director

In Cooperation With

Arkansas Vocational and Technical Education
A Division of the Department of Education
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SOLAR HOTWATER CURRICULUM
TABLE OF CONTENTS

Section A--Related Instructions

Unit I History and Development
Unit II Human Relations
Unit III VICA
Unit IV General Safety
Unit V Building, Plumbing, and Electrical Codes
Unit VI Applying For a Job

Section B--Electricity

Unit I Fumdamentals of Electricity
Unit II Electric Power
Unit III Electrical Test Instruments

Section C--Electric Motors and Controls

Unit I Introduction to Electric Motors
Unit II Split-Phase Motors
Unit III Capacitor Motors

Section D--Tools and Equipment

Unit I Basic Hand Tools
Unit II Solar Technician's Tool Box
Unit III Special Tools
Unit IV Power Tools
Unit V Equipment

Section E--Soldering, Cutting, and Welding

Unit I Soft Soldering
Unit II Oxy-Acetylene Cutting and Welding
Unit III Electric Welding
Unit IV Gas/Tungsten Arc Welding

Section F--Piping

Unit I Pipe
Unit II Pipe Fittings
Unit III Joining Pipe

Section G--Blueprint Reading

Unit I Blueprint Reading

SOLAR HOTWATER CURRICULUM
TABLE OF CONTENTS (CON'T)

Section H--Solar Hotwater Systems

Unit I Components
Unit II System Installation

SOLAR AIR CONDITIONING CURRICULUM
TABLE OF CONTENTS

Section I--Safety in Air Conditioning

Unit I Specific Safety

Section J--Heating and Cooling

Unit I Special Tools
Unit II Solar Assisted Heat Pumps
Unit III Solar Absorption Systems

FOREWORD

This publication is designed to assist teachers in improving instruction. As this material is used, it is hoped that the student performance will improve and that students will be better able to assume a role in an occupation where solar energy skills are applicable.

Instructional materials in this publication are written in terms of student performance using measurable objectives. This is an innovative approach to teaching that accents and augments the teaching/learning process. Criterion referenced evaluation instruments are provided for uniform measurement of student progress. In addition to evaluating recall information, teachers are encouraged to evaluate the other areas including process and product as indicated at the end of each instructional unit.

It is the sincere belief of the writer and all members who served on the advisory committee that this publication will allow the students to become better prepared and more effective members of the work force.

Robert Watson Jr., Instructor
Solar Energy Technology
Delta Vocational Technical School

PREFACE

Every effort has been made to make this publication basic, readable, and by all means, usable. Three vital parts of instruction have been intentionally omitted from this publication: motivation, personalization, and localization. These areas are left to the individual instructors and the instructors should capitalize on them. Only then will this publication really become a vital part of the teaching/learning process.

The tools and equipment included in this curriculum exceed those needed to complete the jobs required in the instructional materials. But as most programs will involve more activities than these basic functions, it was the opinion of the writer that coverage of these extra items was needed to familiarize the solar trainee with the many types of tools and equipment he/she could be called upon to use.

Text references listed with each unit are intended to serve as a listing of available material and are not necessarily used as references in the preparation of this guide.

The list of audiovisuals include only those currently being used by the writer and are not promoted as the only or the best now available.

Audiovisuals can best be selected by the individual instructor to fit her/his program.

Robert Watson Jr.

ACKNOWLEDGMENTS

Appreciation is extended to those individuals who contributed their time and talents to the development of "Solar Hotwater Curriculum".

The contents of this publication were reviewed by:

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Reading of the objectives by the student should be followed by a class discussion to answer any questions concerning performance requirements for each instructional unit.

Teachers should feel free to add objectives which will fit the material to the needs of the students and community. When teachers add objectives, they should remember to supply the needed information, assignment and/or job sheets, and criterion tests.

Suggested Activities

Each unit of instruction has a suggested activities sheet outlining steps to follow in accomplishing specific objectives. The activities are listed according to whether they are the responsibility of the instructor or the student.

Instructor: Duties of the instructor will vary according to the particular unit; however, for best use of the material they should include the following: provide students with objective sheet, information sheet, assignment sheets, and job sheets; preview filmstrips, make transparencies, and arrange for resource materials and people; discuss unit and specific objectives and information sheet; give test. Teachers are encouraged to use any additional instructional activities and teaching methods to aid students in accomplishing the objectives.

Students: Student activities are listed which will help the student to achieve the objectives for the unit.

Information Sheets

Information sheets provide content essential for meeting the cognitive (knowledge) objectives in the unit. The teacher will find that the information sheets serve as an excellent guide for presenting the background knowledge necessary to develop the skill specified in the unit objective.

Students should read the information sheets before the information is discussed in class. Students may take additional notes on the information sheets.

Transparency Masters

Transparency masters provide information in a special way. The students may see as well as hear the material being presented, thus reinforcing the learing process. Transparencies may present new information or they may reinforce information presented in the information sheets. They are particularly effective when identification is necessary.

8

Transparencies should be made and placed in the notebook where they will be immediately available for use. Transparencies direct the class's attention to the topic of discussion. (NOTE: Stand away from the overhead projector when discussing transparency material. The noise of the projector may cause the teacher to speak too loudly.)

Assignment Sheets

Assignment sheets give direction to study and furnish practice for paper and pencil activities to develop the knowledges which are prerequisites to skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided which may be used by the student and/or teacher for checking student progress.

Job Sheets

Job sheets are an important segment of each unit. The instructor should be able to, and in most situations should, demonstrate the skills outlined in the job sheets. Procedures outlined in the job sheets give direction to the skill being taught and allow both student and teacher to check student progress toward the accomplishment of the skill. Job sheets provide a ready outline for students to follow if they have missed a demonstration. Job sheets also furnish potential employers with a picture of the skills being taught and the performances which might reasonably be expected from a person who has had this training.

Test and Evaluation

Paper/pencil and performance tests have been constructed to measure student achievement of each objective listed in the unit of instruction. Individual test items may be pulled out and used as a short test to determine student achievement of a particular objective. This kind of testing may be used as a daily quiz and will help the teacher spot difficulties being encountered by students in their efforts to accomplish the unit objective. Test items for objectives added by the teacher should be constructed and added to the test.

Test Answers

Test answers are provided for each unit. These may be used by the teacher and/or student for checking student achievement of the objectives.

USE OF THIS PUBLICATION

Instructional Units

The Solar Hotwater Systems Curriculum includes six related units, nineteen base units and two hotwater systems units.

The Solar Air Conditioning Curriculum includes one related unit, one base unit and two solar air conditioning units.

Each instructional unit includes some or all of the basic components of a unit of instruction: performance objectives, suggested activities for teachers and students, information sheets, assignment sheets, job sheets, visual aids, tests, and answers to the test. Units are planned for more than one lesson or class period of instruction.

Careful study of each instructional unit by the teacher will help determine:

A. The amount of material that can be covered in each class period
B. The skills which must be demonstrated
    1. Supplies needed
    2. Equipment needed
    3. Amount of practice needed
    4. Amount of class time needed for demonstrations
C. Supplementary materials such as pamphlets or filmstrips that must be ordered
D. Resource people who must be contacted

Objectives

Each unit of instruction is based on performance objectives. These objectives state the goals of the course, thus providing a sense of direction and accomplishment for the student.

Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction; and specific objectives, stating the student performance necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching/learning process, it is important for the teacher and students to have a common understanding of the intent of the objectives. A limited number of performance terms have been used in the objectives for this curriculum to assist in promoting the effectiveness of the communication among all individuals using the materials.

LISTING OF TASKS USED IN THIS PUBLICATION

SECTION	UNIT	TASK
Related Instructions	History and Development	
	Human Relations	
	VICA	
	General Safety	
	Building, Plumbing, and Electrical Codes	
	Applying for A Job	
Electricity	Fundamentals of Electricity	(1) Solder electrical wire joints
	Electric Power	
	Electrical Test Instruments	(1) Use a Voltmeter (2) Use a Ohmmeter (3) Use a Wattmeter (4) Use a Ammeter (5) Use a Capacitor Analyzer (6) Test a Capacitor with an Ohmmeter
Electric Motors and Controls	Introduction to Electric Motors	
	Split-Phase Motors	(1) Wire a split-phase motor to a 115 VAC supply (2) Reverse rotation of a split-phase motor

SECTION	UNIT	TASK
Electric Motors and Controls Con't	Split-Phase Motors	(3) Disassemble, inspect, clean, and reassemble a split-phase motor
	Capacitor Motors	(1) Remove, test, and replace a run capacitor on a P.S.C. pump motor
Tools and Equipment	Basic Hand Tools	(1) Set up and use a Hacksaw
	Solar Technician's Tool Box	
	Special Tools	(1) Sharpen a twist drill bit
	Power Tools	(1) Make 45° angle cuts in Aluminum angle using a bench band saw
		(2) Install an aluminum angle bracket on a concrete block
		(3) Drill a 5/8" round hole in aluminum angle using a round saw and mandrel
	Equipment	(1) Light and adjust the Air-acetylene torch
		(2) Grind a flat tip screwdriver
		(3) Grind the head of a cold chisel or punch
		(4) Sharpen a cold chisel
Soldering, Cutting, and Welding	Soft Soldering	(1) Clean, flux and solder a swage joint
		(2) Solder an inverted swage joint
		(3) Solder a horizontal swage joint

SECTION	UNIT	TASK
Soldering, Cutting, and Welding Con't	Soft Soldering	(4) Soft solder with the oxyacetylene torch
	Oxyacetylene Cutting, Welding, and Brazing	(1) Set up equipment for oxyacetylene cutting
		(2) Turn on, light, adjust to a neutral flame, and turn off the oxyacetylene cutting equipment
		(3) Make 90° cuts on mild steel and restart a cut
		(4) Cut a hole in mild steel
		(5) Lay beads on gauge metal without filler rod
		(6) Lay beads on gauge metal with filler rod
		(7) Weld butt joints with filler rod
		(8) Braze weld a square groove butt joint
	Electric Welding	(1) Start, stop, and restart a bead
		(2) Make a pad in the flat position
		(3) Make a square groove butt weld
		(4) Make a multiple pass T-joint fillet weld
	Gas Tungsten Arc Welding	(1) Set up the GTAW power supply, select and adjust the correct current for aluminum, and shut down the equipment
		(2) Clean Aluminum both mechanically and chemically

SECTION	UNIT	TASK
Soldering Cutting, and Welding Con't	Gas Tungsten Arc Welding	(3) Run stringer beads on one-sixteenth inch aluminum in the flat position with filler rod (4) Construct a square groove butt weld on one-eighth inch aluminum in the flat position with filler rod (5) Construct a lap joint fillet weld on one-eighth inch aluminum in the horizontal position with filler rod (6) Construct an outside corner fillet weld joint on one-eighth inch aluminum in the flat position without filler rod (7) Construct a T-joint fillet weld on one-eighth inch aluminum in the horizontal position with filler rod (8) Construct a T-joint fillet weld on one-eighth inch aluminum in the vertical up position with filler rod
Piping	Pipe	
	Pipe Fittings	
	Joining Pipes	(1) Cut, ream, thread, and join a piece of one inch galvanized steel pipe to a one inch fitting (2) Cut, ream, and join copper tubing using the sweat method

SECTION	UNIT	TASK
Piping Con't	Joining Pipes	(3) Cut, ream, and join copper tubing using a flare joint (4) Cut, ream, and join copper tubing using a hammered flare joint (5) Cut, ream, and join P.V.C. pipe to a P.V.C. fitting
Blueprint Reading	Blueprint Reading	
Solar Hotwater Systems	System Components	(1) Install a residential solar hotwater system with auxiliary gas heater, drain down freeze protection and frost override (2) Check operation of a domestic solar hotwater system with auxiliary gas heater, drain down freeze protection and frost override (3) Install a closed loop domestic solar hotwater system using water/glycol transfer fluid, remote mounted heat exchanger and storage tank with electric backup element
Safety in Air Conditioning	Specific Safety	
Heating and Cooling	Special Tools	
	Solar Assisted Heat Pumps	(1) Install a collector loop for a solar assisted heat pump (2) Install a split-heat pump system (3) Install a storage/terminal loop (4) Install a domestic water heater loop

SECTION	UNIT	TASK
Heating and Cooling (Con't)	Solar Absorption Systems	(1) Assemble a PWF 36-100 package unit and locate support components
		(2) Install piping circuits for an absorption heat/cool package system with drain back collector loop
		(3) Install piping circuits for an absorption heat/cool system storage tank
		(4) Install an evaporative cooling tower for an absorption heat/cool system
		(5) Install a fan-coil unit for a solar absorption heat/cool system
		(6) Install a gas piping circuit for the back-up boiler of an absorption heat/cool system
		(7) Install solar hotwater heater piping circuit
		(8) Install power and control circuits for a solar absorption heat/cool system
		(9) Start-up and check performance of an absorption heat/cool system

TOOLS AND EQUIPMENT
FOR UNITS A-G

Recommended Tools and Equipment necessary to complete the job sheets:

- Hand tool set
- Safety glasses
- Soldering gun
- Volt/ohmmeter
- Wattmeter
- Clamp on type ammeter
- Capacitor analyzer
- Air compressor
- Soft face hammer
- Hack saw
- Pipe Vise
- Twist drill bit set
- Drill bit gauge
- Oil stone
- Bench grinder
- Drill press
- Water tray
- Bench band saw
- Protractor
- Safety goggles
- 3/8" Hammer drill
- 1/4" Masonary drill bit

TOOLS AND EQUIPMENT
CON'T

Metal round hole saw set with mandrel

1/2" Straight drill-115 volt variable speed

Center punch set

Drift punch set

Air-acetylene torch outfit

Striker

Acetylene tank valve wrench

1/2" Cold chisel

Tubing cutter with reamer

Swaging block (flaring block)

5/8" Swaging punch

Ball peen hammer

Tinted safety glasses

2" x 4" c 8" wood block

Air-acetylene tip set - size 2 - 5

Oxy-acetylene torch outfit

Welding tip set

Cutting tip and handle

Welding tip tool

Oxy-acetylene cylinder cart with hose rack

Hose and regulator fitting wrench

Pair of welding gloves

Welding goggles

Vice grip pliers

TOOLS AND EQUIPMENT
CON'T

Welding table

Wire brush

Welding helmet

AC-DC Welder outfit

Chipping hammer

Gas-tungsten welder outfit

Argon gas cylinder

Stainless steel brush

Files for aluminum

1/2" - 2" Pipe die set

Die stock

Set of flat files

Oil can

Pipe cutter

Pipe reamer

Flaring yoke and block

1/2" Hammered flare tool

Miter box

Handsaw (fine tooth)

Measuring tapes with graduations of: sixty-fourths, thirty-seconds, sixteenths, eighths, quarters, and halves

12" Rulers graduated in 1/16, 1/8, and 1/4 inch

Pocket knife

Architect's ruler

Watthour meter

TOOLS AND EQUIPMENT
CON'T

Set of lens for welding goggles

Set of lens for welding helmet

MATERIALS
FOR UNITS A-G

Recommended Materials needed to complete the job sheets in the base units:

Rosin core solder

#16 AWG wire

1/4" Female spade connectors

120 Volt wall outlet circuit

240 Volt wall outlet circuit

240 Volt 1 pH disconnect switch circuit

2 watt 20K ohm bleed resistor

Plug type fuse

1/2 HP 115 volt P.S.C. type circulation pump motor

(NOTE: Instructor selected motor may be used instead.)

3 MFD run capacitor

5 MFD run capacitor

7.5 MFD run capacitor

75 - 100 MFD start capacitor

1/4 HP 115 volt reversable split-phase motor with a two terminal overload

Motor cleaning fluid

Shop towels

1/2" Galvanized pipe

1/6 HP 115 Volt capacitor start motor

1/16" x 2 1/2" x 2 1/2" Aluminum angle

1/4" Plastic anchors

SUPPLIES AND MATERIALS
CON'T

#12 Sheet metal screws

Concrete block

Bottle of soap bubbles

1/2" 1D Copper tubing

Roll of fine sand cloth

Low corrosive paste flux

Roll of 50 - 50 solder

Shop towel

1/2" paint brush

2 Gallon galvanized bucket

1/4" Mild steel plate

1/2" Mild steel plate

Soap stone

Straight edge (12")

16 Gauge mild steel plate

Fire bricks

Selected welding rods

1/8" Mild steel plate

1/8" Bronze welding rods

Bronze welding flux

E-6010 Welding electrodes - 1/8" or 5/32"

3/16" - 3/8" Mild steel plate

E-5010 Electrode - 1/8" or 5/32"

1/4" Aluminum angle

Aluminum filler rods 3/32"

SUPPLIES AND MATERIALS
CON'T

Chemical solution for cleaning aluminum

1/16" Aluminum sheet

1/8" Aluminum filler rods

1/8" Aluminum sheet

Can of cutting oil

1" Galvanized pipe

1" Galvanized pipe union

No. 2 Lead pencils

3/4" 1D copper tubing

3/4" c 90° Sweat copper ells

1/2" 1D Flare nut

3/4" P.V.C. pipe

Cleaning solvent

Nylon bristle brush - 1/2"

P.V.C. pipe cement

3/4" P.V.C. coupling

Assortment of galvanized, copper, P.V.C. and C.P.V.C. fittings

Copies of blueprints for new homes with solar hotwater system included

1/2" and 3/4" flexible hose

TOOLS, MATERIALS, AND EQUIPMENT
FOR UNITS H-J

Tools, materials, and equipment selected by the course instructor to complete all or part of the following job sheets:

A. Install a residential solar hotwater system with auxiliary gas heater, drain down freeze protection and frost override.

B. Install a closed loop domestic solar hotwater system using water/glycol transfer fluid, remote mounted heat exchanger and storage tank with electric backup element.

C. Install a collector loop for a solar assisted heat pump.

D. Install a split-system heat pump.

E. Install a storage/terminal loop

F. Install a domestic water heater preheat loop

G. Assemble a PWF-36-100 solar absorption package unit and locate support components.

H. Install piping circuits for absorption heat/cool package system with drain back collector loop.

I. Install piping circuits for an absorption heat/cool system storage tank.

J. Install an evaporative cooling tower for an absorption heat/cool system.

K. Install a fan-coil unit for a solar absorption heat/cool system.

L. Install gas piping circuit for the back-up boiler and an absorption heat/cool system.

M. Install solar hotwater heater piping circuits.

N. Install power and control circuits for a solar absorption heat/cool system.

O. Start-up and check performance of an absorption heat/cool system.

HISTORY AND DEVELOPMENT
UNIT I

UNIT OBJECTIVE

Upon completion of this unit, the student should be able to match terms and definitions related to the history and development of solar hotwater systems. The student should also be able to list different types of solar hotwater heaters and list the characteristics of the Bailey Freeze-Protection System. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms to their proper definition or description.
2. Match four dates in the history of solar hotwater systems in California to their proper application.
3. List two characteristics of the Day and Night System and give two descriptions of each characteristic.
4. List three characteristics of Bailey's Freeze-Protection System.
5. List three characteristics of the solar hotwater heater systems installed at the Albany, Georgia Housing Project.
6. Select the number of solar units installed by the Tampa, Florida Housing Authority in 1944.
7. List two types of solar hotwater systems presently in general use.

HISTORY AND DEVELOPMENT
UNIT I

SUGGESTED ACTIVITIES

I. Instructor

- A. Provide student with objective sheet.
- B. Provide student with information sheets.
- C. Make transparencies.
- D. Discuss unit and specific objectives.
- E. Discuss information sheets.
- F. Give test.

II. Student:

- A. Read objective sheet.
- B. Study information sheets.
- C. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Transparency masters
  1. TM 1--Thermosiphon Systems
  2. TM 2--Forced Circulation Type
- D. Test
- E. Answers to test

HISTORY AND DEVELOPMENT
UNIT I

INFORMATION SHEET

I. Terms and definitions

- A. Solar collector--A device that houses an absorbent material that collects heat energy from the sun
- B. Absorber--A material that absorbs solar radiation and converts the radiation into thermal energy
- C. Solar radiation--Energy delivered to earth by the sun
- D. Solar storage--A tank used to store solar heated fluids
- E. Heat exchanger--A device that allows heat to be transferred from one medium to another by separate flow chambers or paths
- F. Absorber coating--Materials used to coat a surface to increase its absorption ability

  (NOTE: These are usually flat black paint, black chrome, or selective coating.)
- G. Potable water--Water free from harmful impurities, suited for human consumption
- H. Heat transfer medium--Means of transferring thermal energy from one medium to another

  (NOTE: Water, oil, and other liquids have been used over the years as transport mediums for hotwater systems.)

II. Early history of solar hotwater systems in California.

- A. 1891 - A solar hotwater system utilizing a glass covered box containing water tanks was patented by Clarence Kemp under the name of climax.
- B. 1895 - The rights to Kemp's patent were bought and a business was set up in Pasadena, California.
- C. 1905 - Charles Haskell introduced the Improved Climax with the following characteristics:

1. Flat tank, painted black, and fitted tightly within a glass-covered box
2. Rigidity provided by vertical metal braces inside tank
3. Cold water entered through perforated pipe extending along length of tanks lower end
4. Hot water was drawn off through perforations in top of hot water outlet pipe which extended along length of uppermost end of tank
5. Connected to conventional water heating system for auxiliary heat
6. Usually installed on or in the roof

(NOTE: This type system made use of the difference in density between hot and cold water for circulation between the two tanks.)

D. 1909 - William J. Bailey introduced a new type solar hotwater system under the name of Day and Night, that had the collector and storage tank separation

E. 1927 - Availability of low cost natural gas puts the solar hotwater industry on the back burner for many years.

III. Characteristics of the Day and Night System:

A. Solar collector

1. Shallow-glass covered box, 4" deep, and lined with felt paper
2. Contained 3/4" copper tubing coiled back and forth across a copper sheet to which it was soldered
3. Copper sheet and tubing painted black
4. Produced hotter water faster than tank heaters because a smaller volume of water was heated at a time
5. Increased surface area/gallon of water exposed to the sun

B. Storage tank

1. Heavily insulated

2. Steel tank surrounded by insulation in a wooden box

C. Design

1. Tank bottom connected by pipe to lowest tube in solar collector

2. Tank top connected by pipe to highest tube on the collector

(NOTE: Hot water entering the top of storage tank would force cold water at bottom to flow to bottom of solar collector.)

IV. Characteristics of Bailey's Freeze-Protection System:

A. Solar collector circulation--system independent of storage tank potable water

B. Tubing in collector loop connected to a heat exchange coil inside the storage tank

C. Non-freezing solution circulated through solar collector loop and heat exchanger inside the storage tank

D. Heated solution transferred the collected solar energy to the storage water when passing through the heat exchanger coil

V. Solar hotwater systems in Georgia.

A. 1941 - Savannah Housing Authority installed 480 solar units

B. 1941-49 - Savannah Housing Authority built two housing projects with 650 solar units

C. 1951-53 - Housing project in Albany, Georgia:

1. Characteristics of systems:

a. Separate collector and storage tank

b. Equipped with heat exchanger coils

c. Glycerin used as a heat transfer medium

VI. Solar systems in Florida

A. 1944 - Tampa Housing Authority installed 534 solar units

B. 1944 - Tampa Housing Authority approved the installation of 500 additional solar water heating units

VII. 1980 - Types of solar hotwater systems in general use.

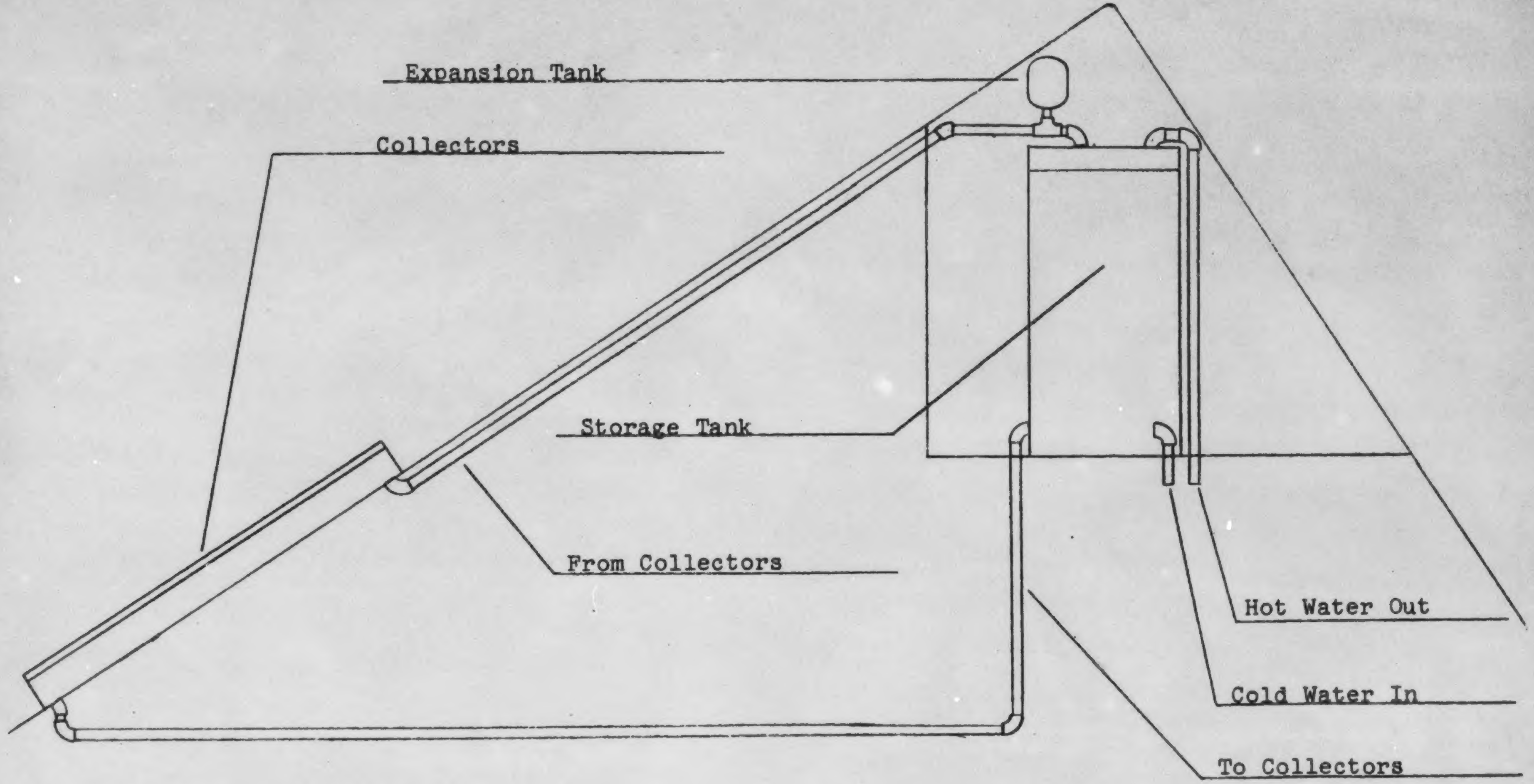
A. Thermosiphon systems

B. Forced circulation type

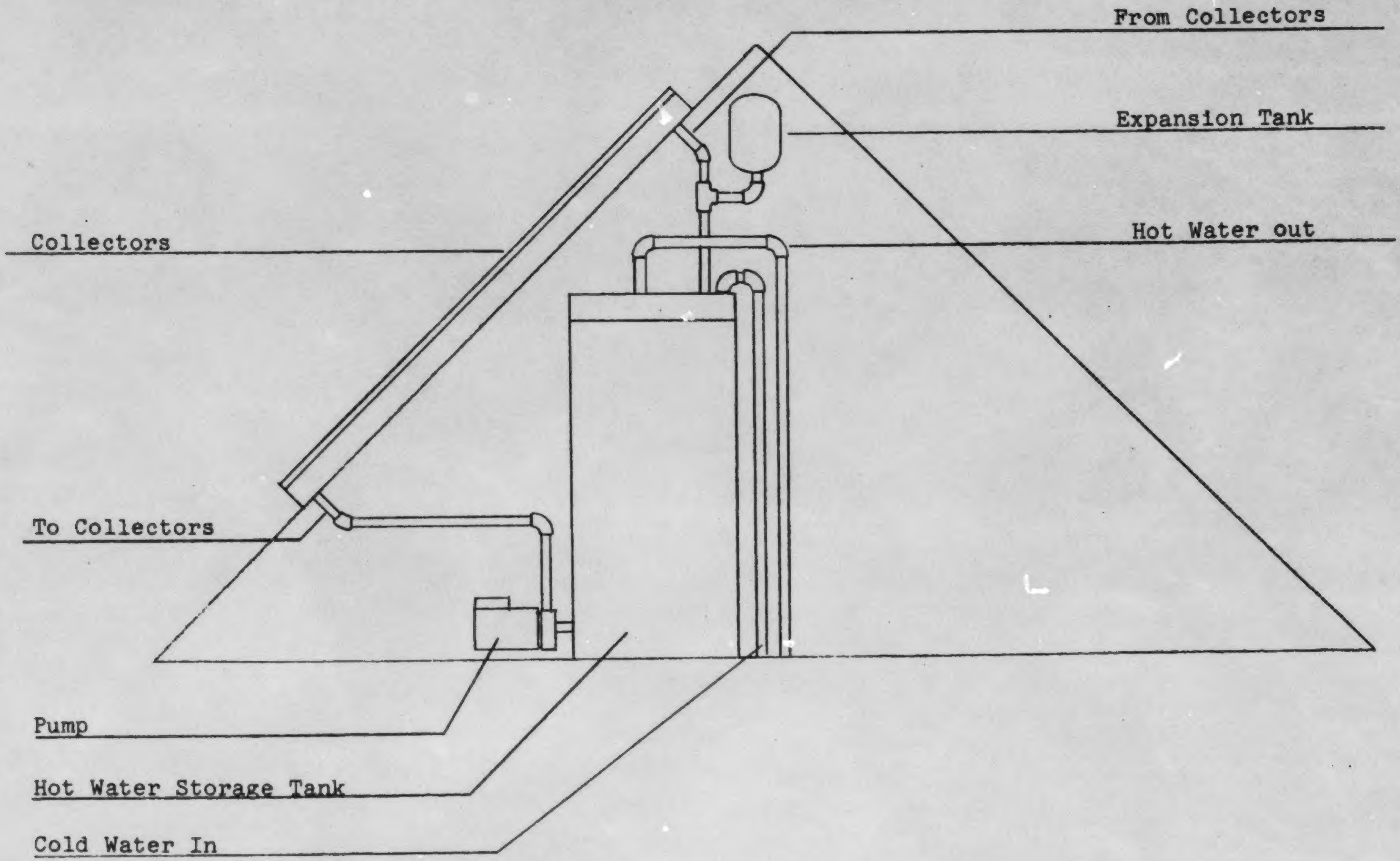
1. With circulation of potable water through the collector loop and back to storage

2. With heat-exchanger

THERMOSYPHON-LOOP SOLAR COLLECTION SYSTEM



FORCED CIRCULATION SYSTEM



HISTORY AND DEVELOPMENT
UNIT I

NAME________________________________

TEST

1. Match the terms on the right to their proper definition or description.

_____a. A device that houses an absorbent material that collects heat energy from the sun

_____b. A material that absorbs solar radiation and converts the radiation into thermal energy

_____c. Energy delivered to earth by the sun

_____d. A tank used to store solar heated fluids

_____e. A device that allows heat to be transferred from one medium to another by separate flow chambers or paths

_____f. Materials used to coat a surface to increase its absorption ability

_____g. Water free from harmful impurities, suited for human consumption

_____h. Means of transferring thermal energy from one medium to another

1. Solar storage
2. Heat transfer medium
3. Solar collector
4. Absorber
5. Potable water
6. Solar radiation
7. Absorber coating
8. Heat exchanger

2. Match the four dates in the history of solar hotwater systems in California, on the right, to their proper application.

_____a. Charles Haskell introduced the Improved Climax solar heater

1. 1895
2. 1905

_____b. The rights to Kemp's patent were bought	3. 1891
	4. 1909
_____c. William J. Bailey introduced the Day and Night Solar Hotwater System	
_____d. A solar hotwater system utilizing a glass covered box containing water tanks was patented by Clarence Kemp under the name of Climax	

3. List two characteristics of the Day and Night System and give two descriptions of each characteristic.

a. ____________________

1. ____

____

2. ____

____

b. ____________________

1. ____

____

2. ____

____

4. List three characteristics of Bailey's Freeze-Protection System.

a. ____

____

b. ____

____

c. ____

____

5. List three characteristics of the solar hotwater heater systems installed at the Albany, Georgia Housing Project.

   a. ____

   b. ____

   c. ____

6. Select the number of solar units installed by the Tampa, Florida Housing Authority in 1944 by placing an "X" in the appropriate blank.

   _____a. 435 units

   _____b. 345 units

   _____c. 543 units

   _____d. 534 units

7. List two types of solar hotwater systems in general use in 1980.

   a. ________________________

   b. ________________________

HISTORY AND DEVELOPMENT
UNIT I

ANSWERS TO TEST

1. a. 3 e. 8
   b. 4 f. 7
   c. 6 g. 5
   d. 1 h. 2

2. a. 2
   b. 1
   c. 4
   d. 3

3. Any two of the following characteristics:

   a. Solar Collector

      Any two of the following descriptions:

      1. Shallow-glass covered box, 4" deep, and lined with felt paper
      2. Contained 3/4" copper tubing coiled back and forth across a copper sheet to which it was soldered
      3. Copper sheet and tubing painted black
      4. Produced hotter water faster than tank heaters because a smaller volume of water was heated at a time
      5. Increased surface area/gallon of water exposed to the sun

   b. Storage tank

      1. Heavily insulated
      2. Steel tank surrounded by insulation in a wooden box

c. Design

1. Tank bottom connected by pipe to lowest tube in solar collector

2. Tank top connected by pipe to highest tube on the collector

4. Any three of the following:

a. Solar collector circulation--system independent of storage tank potable water

b. Tubing in collector loop connected to a heat exchange coil inside the storage tank

c. Non-freezing solution circulated through solar collector loop and heat exchanger inside the storage tank

d. Heated solution transferred the collected solar energy to the storage water when passing through the heat exchanger coil

5. a. Separate collector and storage tank

b. Equipped with heat exchanger coils

c. Glycerin used as a heat transfer medium

6. d.

7. a. Thermosiphon type

b. Forced circulation type

HUMAN RELATIONS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with the human relations required of a solar technician and be able to distinguish between important aspects of employer-employee relationships. The student should also be able to explain the reasons for teamwork and select conditions which enhance good custumer relations. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with human relations to the correct definitions.
2. Distinguish between employer expectations and employee expectations in their relationship.
3. Match statements dealing with desirable personality traits and attitudes to their proper application.
4. Explain three reasons for teamwork.
5. Select those conditions which enhance good customer relations.

HUMAN RELATIONS
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information sheet.

  C. Make transparency.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Discuss human relations as they apply to the solar technician

  G. Invite a solar contractor to speak to the class.

  H. Give examples of human relations.

  I. Give test.

II. Students:

  A. Read objective sheet.

  B. Study information sheet.

  C. Participate in class discussion on human relations.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Test

  D. Answers to test

HUMAN RELATIONS
UNIT II

INFORMATION SHEET

I. Terms and definitions

- A. Employee--Person employed by another, usually for wages or salary
- B. Employer--Person who employs others usually for wages or salary
- C. Teamwork--Work done by several persons with each doing a part but all giving attention to the efficiency of the whole project
- D. Customer relations--Attitude, interest, and/or relationship of the customer in respect to the actions of any of the employees or employers of a sales business

II. Expectations of the employer and employee in their relationship

- A. Employer expectations
    1. Cooperation
    2. Honesty
    3. Initiative
    4. Willingness to learn
    5. Willingness to follow directions
    6. Dependability
    7. Enthusiasm
    8. Acceptance of objective criticism
    9. Loyalty and respect
    10. Full day's work for a full day's pay
    11. Notification of termination
    12. Productivity

B. Employee expectations

1. Salary
2. Safe working conditions
3. Training
4. Introduction to co-workers
5. Explanation of policies, rules, and regulations
6. Duty changes
7. Evaluation of work
8. Discipline for breaking rules
9. Honest relationship
10. Notification if employment is terminated
11. Respect

III. Desirable personality traits and attitudes

A. Adaptability--Adjusting easily to new situations

1. Accept changes without complaint
2. Learn new procedures and service information

B. Cooperation--Working harmoniously with others

1. Help others when possible
2. Work well with co--workers, supervisor, and employer

C. Courtesy--Being polite and having good manners

1. Show respect for employer
2. Show respect for the customer

D. Dependability--Doing what a person says he/she will and completing duties assigned to him/her

1. Work regularly
2. Be on time
3. Take only the time allowed for lunch and breaks

INFORMATION SHEET

4. Do all work assigned

E. Honesty--Being truthful in all things

1. Give truthful information to employers, customers, and co-workers

2. Keep promises

F. Initiative--Doing things without being told

1. Use slack moments or leisure time to learn more about job

2. Show an interest in learning and doing a good job

3. Suggest ideas

4. Anticipate needs for a job

G. Loyalty--Supporting a cause

1. Keep confidences

2. Avoid public criticisms of employer, supervisor, or co-workers

H. Self-control--Being able to control one's temper and emotions

1. Control temper

2. Accept objective criticism

3. Maintain poise

I. Tact--Being able to say the right thing at the right time

1. Do not correct customers, co-workers, and employer in a disagreeable manner

2. Learn to take care of customer complaints

IV. Reasons for teamwork

A. Provides for the work to be done quickly

B. Provides for the work to be equally shared

- C. Provides for heavy loads to be handled more easily
- D. Provides for a degree of comradeship rather than isolation
- E. Provides for difficult jobs to be done easily

V. Conditions which enhance good customer relations

- A. Honesty
- B. Courtesy and politeness
- C. Neatness and cleanliness
- D. Fairness
- E. Effective communications
- F. Promptness

HUMAN RELATIONS
UNIT II

NAME ______________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Attitude, interest and/or relationship of the customer in respect to the actions of any of the employees or employers of a sales business

_____b. Person who employs others usually for wages or salary

_____c. Work done by several persons with each doing a part but all giving attention to the efficiency of the whole project

_____d. Person employed by another, usually for wages or salary

1. Teamwork
2. Employee
3. Customer relations
4. Employer

2. Distinguish between employer expectations and employee expectations by placing an "X" next to employer expectations.

_____a. Cooperation

_____b. Initiative

_____c. Safe working conditions

_____d. Loyalty and respect

_____e. Explanation of policy, rules, and regulations

_____f. Discipline for breaking rules

_____g. Acceptance of objective criticism

_____h. Full day's work for a full day's pay

_____i. Notification of termination

_____j. Training

_____k. Evaluation of work

_____l. Dependability

_____m. Productivity

3. Match the statements on the right to their proper application for desirable personality traits and attitudes

A. Adaptability

1. _____
2. _____

B. Cooperation

1. _____
2. _____

C. Courtesy

1. _____
2. _____

D. Dependability

1. _____
2. _____
3. _____
4. _____

E. Honesty

1. _____
2. _____

F. Initiative

1. _____
2. _____
3. _____
4. _____

a. Show respect for employer

b. Work regularly

c. Accept changes with complaint

d. Keep promises

e. Learn to handle customer complaints

f. Learn new procedures and service information

g. Help others when possible

h. Work well with co-workers, supervisor and/or employer

i. Keep confidences

j. Be on time

k. Anticipate needs for a job

m. Control temper

n. Do all work assigned

o. Suggest ideas

p. Avoid public criticisms of employer, supervisor, or co-worker

q. Show an interest in learning and doing a good job

r. Accept objective criticism

s. Do not correct customers, co-workers, or employer in a disagreeable manner

G. Loyalty

1. _____
2. _____

H. Self-control

1. _____
2. _____
3. _____

I. Tact

1. _____
2. _____

t. Use slack moments or leisure time to learn more about job

u. Give truthful information to employers, customers and co-workers

v. Take only the time allowed for lunch and breaks

w. Show respect for the customer

x. Maintain poise

4. Explain three reasons for teamwork.

a.

b.

c.

5. Select conditions which enhance good customer relations by placing an "X" in the appropriate blanks.

_____a. Honesty

_____b. Fairness

_____c. Salary

_____d. Neatness and cleanliness

HUMAN RELATIONS
UNIT II

ANSWERS TO TEST

1. a. 3 c. 1
   b. 4 d. 2
2. a, b, d, g, h, i, l, m
3. A. 1. c
      2. f
   B. 1. g
      2. h
   C. 1. a
      2. w
   D. 1. b
      2. j
      3. v
      4. h
   E. 1. u
      2. d
   F. 1. t
      2. q
      3. o
      4. k
   G. 1. i
      2. p
   H. 1. m
      2. y
      3. x

I. 1. s

2. e

4. Any three of the following:

   a. Provides for the work to be done quickly

   b. Provides for the work to be equally shared

   c. Provides for heavy loads to be handled more easily

   d. Provides for a degree of comradeship rather than isolation

   e. Provides for difficult jobs to be done easily

5. a, b, d

VICA
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to name the purposes of the VICA organization and write the VICA motto. The student should be able to identify the symbols of the VICA emblem and tell what each represents. He/she should also be able to write what each color of the VICA organization represents and the emphasis of the VICA creed. This knowledge will be evidenced by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Name five purposes of the VICA organization.
2. Write from memory the VICA motto.
3. List three committments of the VICA pledge.
4. Name three beliefs the VICA creed emphasizes.
5. Write what each color of the VICA organization represents.
6. Identify the symbols of the VICA emblem and write what each symbol represents.

VICA
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide students with objective sheet.

   B. Provide students with information sheet.

   C. Make transparency.

   D. Discuss terminal and specific objectives.

   E. Discuss information sheet.

   F. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency master: TM 1--Symbols of the VICA Emblem

   D. Test

   E. Answers to test

II. Reference: Official Guide. Washington, D.D.: Vocational Industrial Clubs of America, Vocational Industrial Clubs of America, Inc., 1025 15th Street N.W., Washington, D.C. 20005.

VICA
UNIT III

INFORMATION SHEET

I. Purposes of the VICA organization

   A. To unite in a common bond all students enrolled in trade and industrial education

   B. To develop leadership abilities through participation in educational, vocational, civic, recreational, and social activities

   C. To foster a deep respect for the DIGNITY OF WORK

   D. To assist students in establishing realistic vocational goals

   E. To help students attain a purposeful life

   F. To create enthusiasm for learning

   G. To promote high standards in trade ethics, workmanship, scholarship, and safety

   H. To develop the ability of students to plan together, organize, and carry out worthy activities and projects through use of the democratic process

   I. To foster a wholesome understanding of the functions of labor and management organizations and a recognition of their mutual interdependence

   J. To create among students, faculty members, patrons of the school, and persons in business and labor a sincere interest in and esteem for trade, industrial, and technical education

   K. To develop patriotism through a knowledge of our Nation's heritage and the practice of DEMOCRACY

II. VICA motto--Preparing for Leadership in the World of Work

III. VICA pledge--UPON MY HONOR, I pledge

   A. To prepare myself by diligent study and ardent practice to become a worker whose services will be recognized as honorable by my employer and fellow workers

B. To base my expectations of reward upon the solid foundation of service

C. To honor and respect my vocation in such a way as to bring repute to myself

D. And further, to spare no effort in upholding the ideals of the Vocational Industrial Clubs of America

IV. VICA creed--Emphasizes a belief in

A. The dignity of work

B. The American way of life

C. Education

D. Fair play

E. Satisfaction achieved by good work

F. High moral and spiritual standards

V. Colors of the VICA organization

A. Red and white--Represent the individual states and clubs

B. Blue--Represents the common union of the states and of the clubs

C. Gold--Represents the individual

VI. Symbols of the VICA emblem (Transparency 1)

A. Shield--Represents patriotism

B. Torch--Represents knowledge

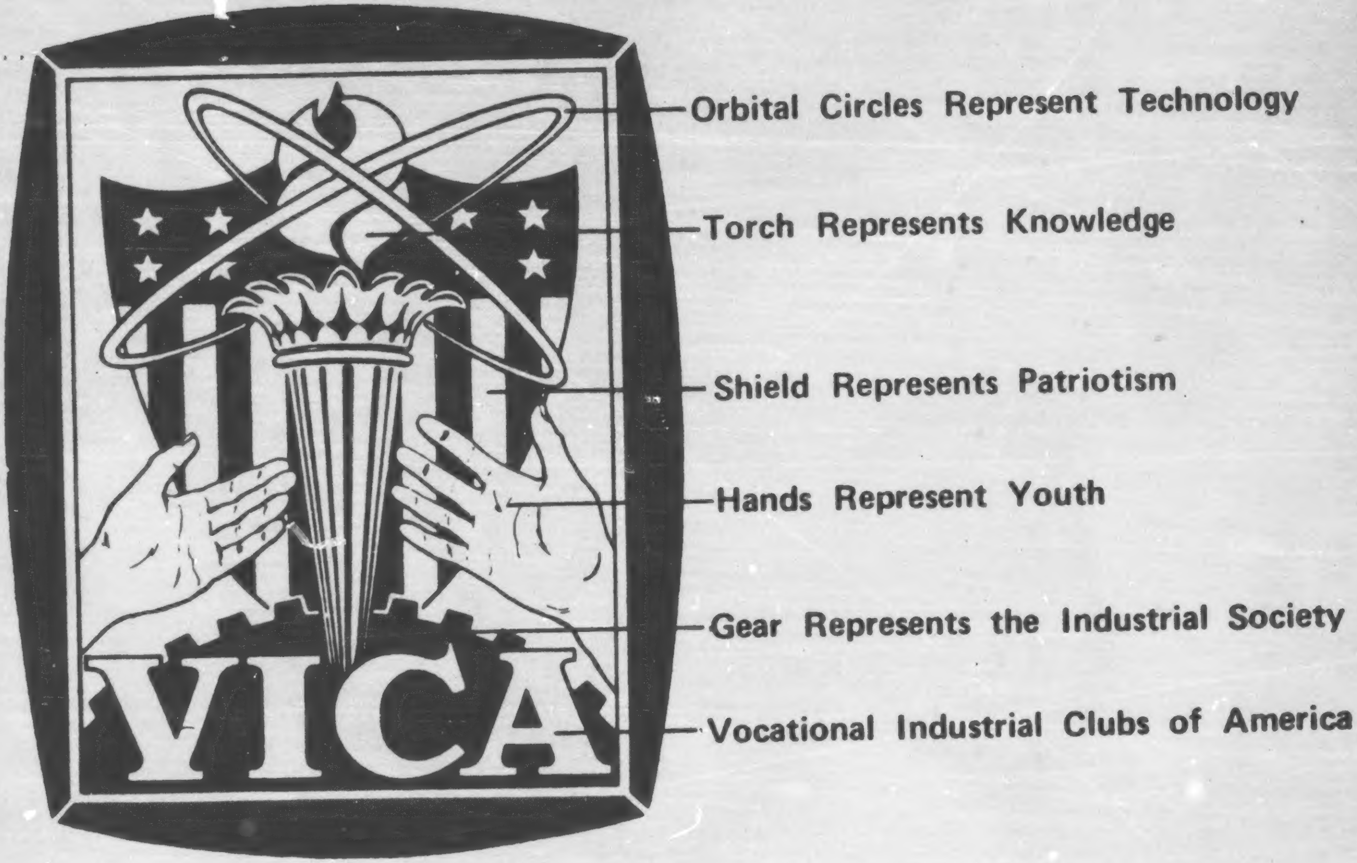
C. Orbital circles--Represent technology

D. Gear--Represents the industrial society

E. Hands--Represent youth

F. VICA--Represents Vocational Industrial Clubs of America

Symbols of the VICA Emblem


VICA
Orbital Circles Represent Technology
Torch Represents Knowledge
Shield Represents Patriotism
Hands Represent Youth
Gear Represents the Industrial Society
Vocational Industrial Clubs of America

VICA
UNIT III

NAME________________________

TEST

1. Name five purposes of the VICA organization.

   a. ________________________

   b. ________________________

   c. ________________________

   d. ________________________

   e. ________________________

2. Write the VICA motto. ________________________

3. List three committments of the VICA pledge.

   a. ________________________

   b. ________________________

   c. ________________________

4. Name three beliefs the VICA creed emphasizes.

a. ____

____

b. ____

____

c. ____

____

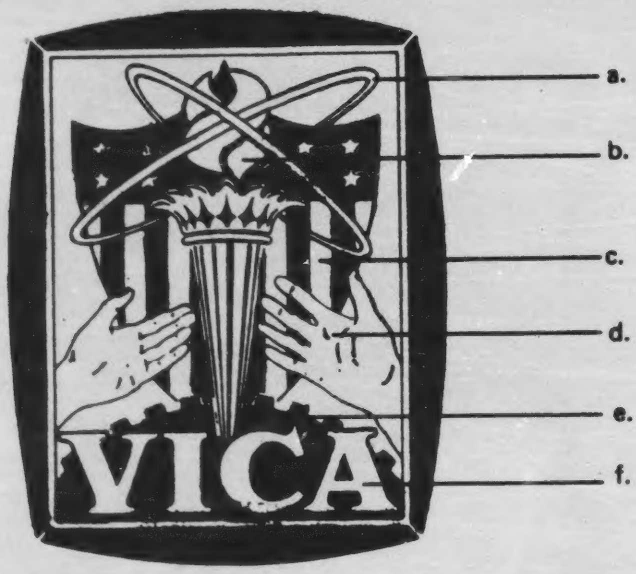
5. Write what each color of the VICA organization represents.

a. Red and White--______________________________

b. Blue--______________________________________

c. Gold--______________________________________

6. Identify the following symbols and tell what each symbol represents.



a. ______________ Represents ______________

____

b. ______________ Represents ______________

____

c. ______________ Represents ______________

____

d. ______________ Represents ______________

____

e. ______________ Represents ______________

____

f. ______________ Represents ______________

____

VICA
UNIT III

ANSWERS TO TEST

1. Any five of the following:

   a. To unite in a common bond all students enrolled in trade and industrial education

   b. To develop leadership abilities through participation in educational, vocational, civic, recreational, and social activities

   c. To foster a deep respect for the DIGNITY OF WORK

   d. To assist students in establishing realistic vocational goals

   e. To help students attain a purposeful life

   f. To create enthusiasm for learning

   g. To promote high standards in trade ethics, workmanship, scholarship, and safety

   h. To develop the ability of students to plan together, organize, and carry out worthy activities and projects through use of the democratic process

   i. To foster a wholesome understanding of the functions of labor and management organizations and a recognition of their mutual interdependence

   j. To create among students, faculty members, patrons of the school, and persons in business and labor a sincere interest in and esteem for trade, industrial, and technical education

2. VICA motto--Preparing for Leadership in the World of Work

3. Any three of the following:

   a. To prepare myself by diligent study and ardent practice to become a worker whose services will be recognized as honorable by my employer and fellow workers

   b. To base my expectations of reward upon the solid foundation of service

c. To honor and respect my vocation in such a way as to bring repute to myself

d. And further, to spare no effort in upholding the ideals of the Vocational Industrial Clubs of America

4. Any three of the following:

   a. The dignity of work

   b. The American way of life

   c. Education

   d. Fair play

   e. Satisfaction achieved by good work

   f. High moral and spiritual standards

5. a. Red and white--Represent the individual states and clubs

   b. Blue--Represents the common union of the states and of the clubs

   c. Gold--Represents the individual

6. a. Orbital circles--Represent technology

   b. Torch--Represents knowledge

   c. Shield--Represents patriotism

   d. Hands--Represent youth

   e. Gear--Represents the industrial society

   f. VICA--Represents Vocational Industrial Clubs of America

GENERAL SAFETY
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to list rules for personal safety and select rules for general shop and field safety. The student should also be able to select the correct fire extinguisher for the classes of fire and match the safety color code with statements of its use. This knowledge will be evidenced by correctly performing the procedures outlined on the assignment sheet and by scoring 100 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with general safety to the correct definitions.
2. Match the seven colors of the safety color code to the correct applications of their use.
3. List four rules for personal safety.
4. Select rules for general shop and field safety.
5. List five steps in maintaining a clean and orderly shop.
6. Match the classes of fire to the correct statements defining each class.
7. Label the three components of the fire triangle.
8. Match the type or types of fire extinguishers to the class of fire they are used on.
9. Select steps to be followed in case of an accident in the solar shop.
10. Select the proper steps for lifting heavy objects.
11. Demonstrate the ability to:
    A. Describe the steps to be followed in case of an accident.

GENERAL SAFETY
UNIT IV

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet.
- B. Provide student with information and assignment sheets.
- C. Make transparencies.
- D. Discuss unit and specific objectives.
- E. Discuss information and assignment sheets.
- F. Show a safety film if available.
- G. Invite fire chief to give a talk on fire safety.
- H. Demonstrate the procedure for lifting a heavy object.
- I. Demonstrate evacuation plan.
- J. Have an accident victim address the class.
- K. Have a paramedic visit the class.
- L. Give test.

II. Student:

- A. Read objective sheet.
- B. Study information sheet.
- C. Complete assignment sheet.
- D. Complete activities assigned by instructor.
- E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet

C. Transparency masters

1. TM 1--The Fire Triangle

2. TM 2--Types of Fire Extinguishers

3. TM 3--Lifting

D. Assignment Sheet #1--Describe the Steps to be Followed in Case of an Accident

E. Answers to assignment sheet

F. Test

G. Answers to test

II. References:

A. The ABC's of Fire Protection. Belleville, New Jersey: Kidde Portable Extinguishers/Walter Kidde and Co., Inc.

B. An Accident Prevention Program for School Shops and Laboratories. Washington, D.C.: Office of Education/U.S. Department of Health, Education, and Welfare.

C. Federal Register. Vol. 36. Number 105. Part II. Department of Labor, May 29, 1971.

D. Safety Practices and Procedures in School Shops. Division of Vocational Education/New Jersey Department of Education.

E. A Look at Service Safety. Tecumseh, Michigan: Tecumseh Products Co.

III. Additional materials:

A. Film--"Housekeeping Means Safekeeping." 146-009. Journal Films Inc., 930 Pinter Avenue, Evanston, Illinois 60202.

B. Film--"Stop a Fire Before it Starts." 146-024, Journal Films, 909 West Diversey Parkway, Chicago, Illinois 60614.

GENERAL SAFETY
UNIT IV

INFORMATION SHEET

I. Terms and definitions

   A. Safety--State or condition of being safe; freedom from danger, risk, or injury

   B. Accident--Includes any suddenly occurring, unintentional event which causes injury or property damage

   C. First aid--Immediate, temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

   D. O.S.H.A.--Occupational Safety and Health Act; federal legislation designed to insure safe and sanitary working conditions for employees

   (NOTE: Refer to your own state organization.)

II. Colors and applications of the safety color code

   (NOTE: Refer to the National Safety Code.)

   A. Federal safety red

      1. Location of fire fighting equipment

      2. Portable containers of flammable liquids

      3. Emergency stop bars, stop buttons, and emergency electrical stop switches on machinery

   B. Federal safety yellow

      1. Caution and for marking physical hazards

      2. Waste containers for explosive or combustible materials

      3. Caution against starting, using, or moving equipment under repair

      4. Identification of the starting point or power source of machinery

C. Federal safety orange

   1. Dangerous parts of machines

   2. Safety starter buttons and parts of equipment that may cause electrical shock

   3. Exposed parts (edges only) of pulleys, gears, rollers, cutting devices, and power jaws

D. Federal safety purple--radiation hazards

E. Federal safety green

   1. Safety

   2. Location of first aid equipment

   (NOTE: This applies to equipment other than fire fighting equipment.)

F. Federal safety black

   1. Traffic flow

   2. Housekeeping purposes

G. Federal safety white

   1. Traffic flow

   2. Housekeeping purposes

   (NOTE: Black and white are used individually or in combination.)

III. Rules for personal safety

   A. Wear appropriate shop clothing

   B. Confine long hair before operating rotating equipment

   C. Always wear safety glasses during shop activities

   D. Remove ties when working around machine tools or rotating equipment

   E. Use proper helmets and safety glasses for welding

IV. Rules for general shop and field safety

INFORMATION SHEET

A. Tools and equipment

1. Keep all hand tools clean, and in safe working order
2. Report any defective tools, machines, or other equipment to the instructor
3. Retain all guards and safety devices except with the specific authorization of the instructor
4. Operate a hazardous machine only after receiving instruction on how to operate the machine safely
5. Turn off the power before leaving a power tool
6. Make sure all guards and barriers are in place and adjusted properly before starting a machine tool
7. Disconnect the power from machine tools before performing the maintenance task of oiling or cleaning
8. Use a solvent only after determining its properties, what kind of work it has to do, and how to use it
9. Use correct, properly fitting wrenches for nuts, bolts, and objects to be turned or held
10. Use proper tools and equipment for the proper job
11. All revolving machine parts should be well guarded
12. Do not run over extension or drop cords with appliance dolly
13. Do not leave tools on the floor
14. Make sure everyone is clear if using compressed air to clean

B. Accidents and safety

1. Report all accidents to the instructor regardless of nature or severity
2. Wear safety clothing such as goggles, gloves, shoes, and aprons when welding

3. Consider the safety of others when working in the shop
4. Report any condition that may lead to an accident
5. Watch the bulletin board for safety information and notices
6. Conduct oneself in a safe-like manner at all times
7. Do not throw any object
8. Control temper and don't take chances
9. Wear gloves when handling material with sharp edges
10. Operate equipment and machines only when permitted by instructor
11. Do not distract the attention of a machine operator while working
12. Do only approved work in shop
13. Check all equipment before turning on switch
14. Do not work in the dark; use plenty of light
15. All accidents should be recorded in writing
16. All injuries must be given prompt attention
17. Do not work overtime in the shop without the instructor being present

C. Housekeeping

1. Keep the shop or job site floor clear of scraps and litter
2. Clean up any spilled liquids immediately
3. Store oily shop towels or oily waste in metal containers
4. Clean the chips from a machine with a brush; do not use a towel, bare hands or compressed air

INFORMATION SHEET

V. Steps in maintaining a clean and orderly shop

  A. Machinery and equipment arranged to permit safe, efficient work practices and ease in cleaning

  B. Materials and supplies safely stacked or stored in proper places

  C. Tools and accessories safely stored in cabinets, on racks, or other suitable devices

  D. Working areas and work benches clear and free of debris and other hazards

  E. Floors clean and free from obstructions and slippery substances

  F. Aisles, traffic areas, and exits free of materials and other debris

  G. Combustible materials properly disposed of or stored in approved, labeled containers

  H. Oily towels stored in approved metal containers

  I. Students working in the area instructed on the proper procedures to follow in keeping the area clean and orderly

  J. Sufficient brooms, brushes, and other housekeeping equipment readily available

  K. Drinking fountain and wash facilities should be kept clean and neat at all times

VI. Classes of fires

  A. Class A--Fires that occur in ordinary combustible materials

  Examples: Wood, rags, and rubbish

  B. Class B--Fires that occur with flammable liquids

  Examples: Gasoline, oil, grease, paints, and thinners

  C. Class C--Fires that occur in or near electrical equipment

  Examples: Motors, switchboards, and electrical wiring

D. Class D--Fires that occur with combustible metals

Example: Magnesium

VII. Components of the fire triangle (Transparency 1)

A. Fuel--Any combustible material

B. Heat--Enough to raise the fuel to its ignition temperature

C. Oxygen--Necessary to sustain combustion

(NOTE: To produce fire these three elements are necessary and must be present at the same time. If any one of the three is missing, a fire cannot be started. With the removal of any one of them, the fire will be extinguished.)

VIII. Types of fire extinguishers and classes of fires (Transparency 2)

A. Pressurized water--Operates usually by squeezing a handle or trigger; used on Class A fires

B. Soda acid--Operates by turning extinguisher upside down; used on Class A fires

C. Carbon dioxide (CO_2)--Operates usually by squeezing handle or trigger; used on Class B and C fires

D. Dry chemical--Operates usually by squeezing a handle, trigger, or lever; used on Class B, C, and D fires

(NOTE: On Class D fires, dry sand is as effective as any dry chemical other than Purple X. The cost of the Purple X chemical places it out of reach of most shops.)

E. Foam--Operates by turning extinguisher upside down; used on Class A and B fires

IX. Steps to be followed in case of an accident in the shop

A. Report all accidents and injuries to the instructor no matter how minor they may seem

B. First aid will be administered if needed

(NOTE: Check with local school policy.)

INFORMATION SHEET

X. Steps for lifting heavy objects (Transparency 3)

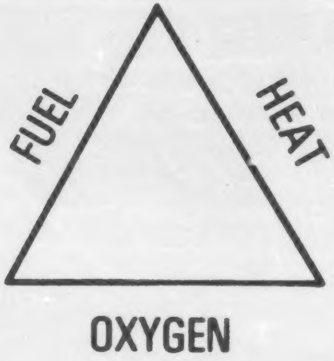
  A. Bend knees

  B. Keep back straight

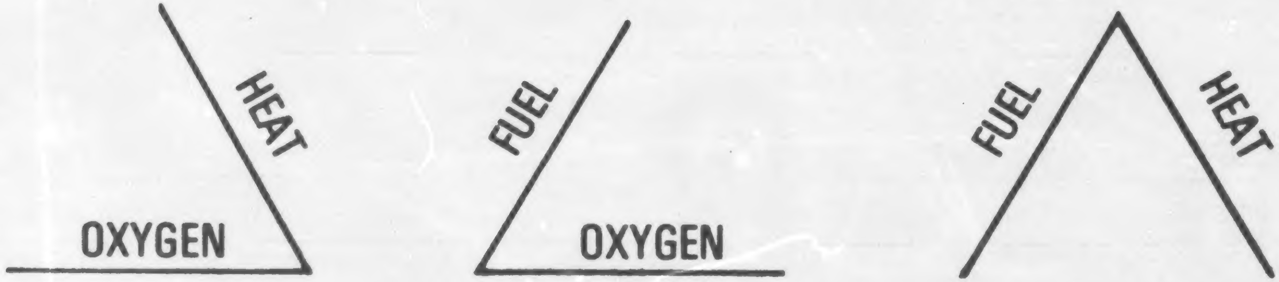
  C. Lift gradually with leg muscles

The Fire Triangle

To produce fire, three things must be present at the same time.



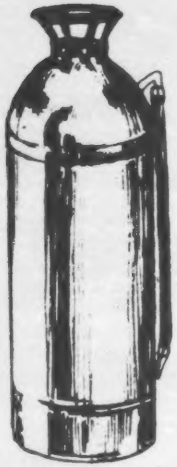
If any one of the three is missing, a fire cannot be started or, with the removal of any one, the fire will be extinguished.



Types of Fire Extinguishers

Pressurized Water

Class A



Soda-Acid

Class A

Carbon Dioxide

Class B and C

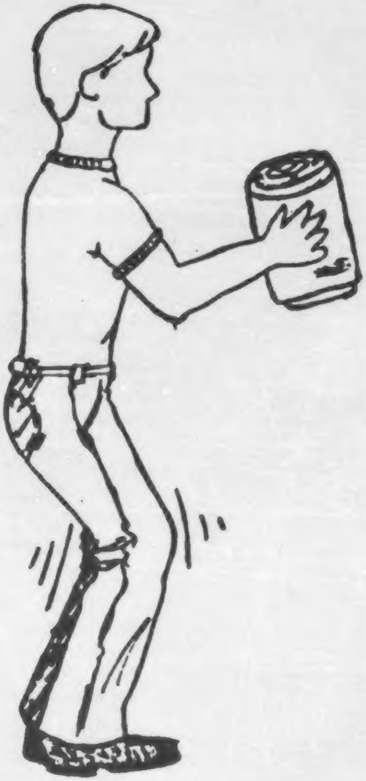
Dry Chemical

Class B, C, and D

Foam

Class A and B

Lifting



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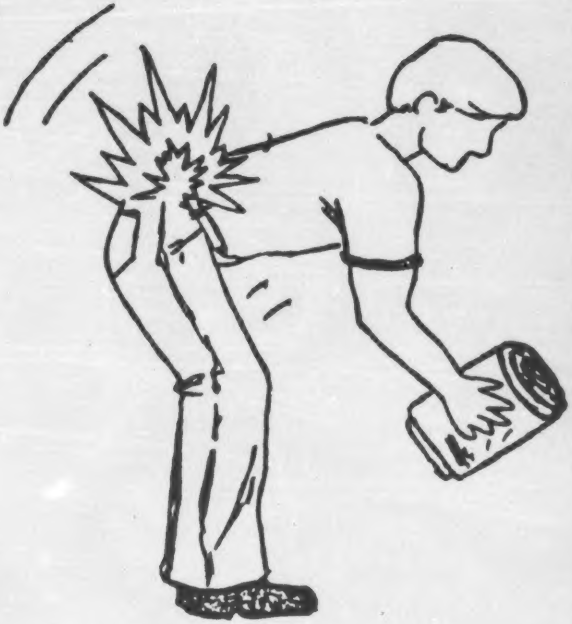

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GENERAL SAFETY
UNIT IV

ASSIGNMENT SHEET #1--DESCRIBE THE STEPS TO BE FOLLOWED IN CASE OF AN ACCIDENT

Given the accident below, list two steps to be followed and state the safety rule that would have prevented the accident from occurring.

A student is removing a sheet metal panel and cuts the palm of his hand to the bone.

Steps:

1. ____

2. ____

Safety Rule

____

____

GENERAL SAFETY
UNIT IV

ANSWERS TO ASSIGNMENT SHEET #1

1. Report all accidents and injuries to the instructor no matter how minor they may seem
2. First aid will be administered if needed

(NOTE: Check with local school policy.)

The safety rule should be stated as follows:

Wear gloves when handling material with sharp edges.

GENERAL SAFETY
UNIT IV

NAME________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Immediate, temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

_____b. State or condition of being safe; freedom from danger, risk, or injury

_____c. Includes any suddenly occurring, unintentional event which causes injury or property damage

_____d. Occupational Safety and Health Act; federal legislation designed to insure safe and sanitary working conditions for employees

1. Safety
2. Accident
3. First aid
4. O.S.H.A.

2. Match the colors of the safety color code on the right to the correct applications of their use.

_____a. Caution and for marking physical hazards

_____b. Location of fire fighting equipment

_____c. Location of first aid equipment

_____d. Dangerous parts of machines

_____e. Housekeeping purposes

_____f. Traffic flow

_____g. Radiation hazards

1. Federal safety green
2. Federal safety white
3. Federal safety orange
4. Federal safety purple
5. Federal safety black
6. Federal safety red
7. Federal safety yellow

3. List four rules for personal safety.

a.

b.

c.

d.

4. Select rules for general shop and field safety by placing an "X" in the appropriate blanks.

_____a. Keep all hand tools clean and in safe working order

_____b. Operate a hazardous machine if you think you can operate the machine

_____c. Report all accidents to the instructor regardless of nature or severity

_____d. Leave the power on a machine tool so the next person may operate it

_____e. Oil or clean machine tools with the power on

_____f. Use correct, properly fitting wrenches for nuts, bolts, and objects to be turned or held

_____g. Throw scraps and litter on the shop floor

_____h. Let spilled liquids stay on the floor until they dry out

_____i. Store oily shop towels or oily waste in metal containers

_____j. Use bare hands to clean chips from a machine

_____k. Wear safety clothing such as goggles, gloves, shoes, and aprons when welding

_____l. Report any condition that may lead to an accident

_____m. Show your temper and take chances while working in the shop

_____n. Wear gloves when handling material with sharp edges

_____o. Do not distract the attention of a machine operator while working _____p. Make sure everyone is clear if using compressed air to clean

_____q. All revolving machine parts should be well guarded

5. List five steps in maintaining a clean and orderly shop.

a.

b.

c.

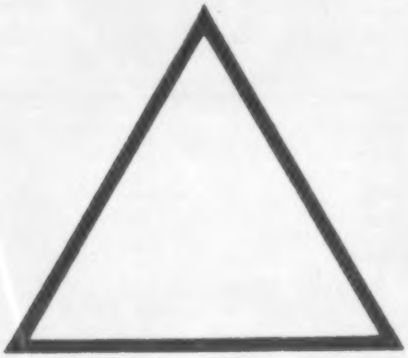
d.

e.

6. Match the classes of fire on the right to the correct statements defining each class.

_____a. Fires that occur with flammable liquids	1. Class A
_____b. Fires that occur in ordinary combustible materials	2. Class B
_____c. Fires that occur in or near electrical equipment	3. Class C
_____d. Fires that occur with combustible metals	4. Class D

7. Label the three components of the fire triangle.



8. Match the type or types of fire extinguishers on the right to the class of fire they are used on.

_____a. Class B

_____b. Class C

_____c. Class A

_____d. Class D

1. Pressurized water
2. Carbon dioxide (CO_2)
3. Dry chemical
4. Soda acid
5. Foam

9. Select two steps to be followed in case of an accident in the solar shop by placing an "X" in the appropriate blanks.

_____a. Investigation of the accident will take place to determine the cause of the accident and determine ways to prevent the same accident from happening again

_____b. Apply a tourniquet

_____c. Student's parent or guardian will be notified if school nurse requires student to see a physician

_____d. First aid will be administered if needed

_____e. Mouth-to-mouth resuscitation will be administered in all cases

_____f. Student will be taken to school nurse

_____g. Student will be required to sign an insurance release form before he or she can be helped

_____h. Report all accidents and injuries to the instructor no matter how minor they may seem

_____i. First mop up blood to prevent a slick spot on floor

_____j. Accident report form will be filled out by instructor

10. Select the proper steps for lifting heavy objects by placing an "X" in the appropriate blanks.

_____a. Bend at the waist and lift straight up

_____b. Keep back straight

_____c. Straddle heavy objects before trying to lift

_____d. Bend knees

_____e. Lift in a quick jerking motion

_____f. Lift gradually with leg muscles

11. Describe the steps to be followed in case of an accident

(NOTE: If this activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

GENERAL SAFETY
UNIT IV

ANSWERS TO TEST

1. a. 3
   b. 1
   c. 2
   d. 4
2. a. 7
   b. 6
   c. 1
   d. 3
   e. 2 and/or 5
   f. 2 and/or 5
   g. 4
3. Any four of the following:
   a. Wear appropriate shop clothing
   b. Confine long hair before operating rotating equipment
   c. Always wear safety glasses during shop activities
   d. Remove ties when working around machine tools or rotating equipment
   e. Use proper helmets and safety glasses for welding
4. a, c, f, i, k, l, n, o, p, q
5. Any five of the following:
   a. Machinery and equipment arranged to permit safe, efficient work practices and ease in cleaning
   b. Materials and supplies safely stacked or stored in proper place
   c. Tools and accessories safely stored in cabinets, on racks, or other suitable devices
   d. Working areas and work benches clear and free of debris and other hazards.

e. Floors clean and free from obstructions and slippery substances

f. Aisles, traffic areas, and exits free of materials and other debris

g. Combustible materials properly disposed of or stored in approved, labeled containers

h. Oily towels stored in approved metal containers

i. Students working in the area instructed on the proper procedures to follow in keeping the area clean and orderly

j. Sufficient brooms, brushes, and other housekeeping equipment readily available

k. Drinking fountain and wash facilities should be kept clean and neat at all times

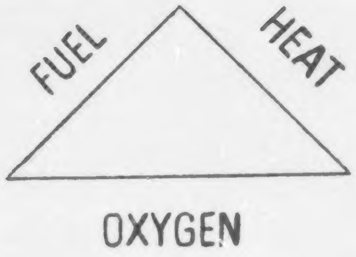
6. a. 2

b. 1

c. 3

d. 4

7.



8. a. 2, 3, and 5

b. 2 and 3

c. 1, 4, and 5

d. 3

9. a, c, d, f, h, j

10. b, d, f

11. Evaluated to the satisfaction of the instructor

BUILDING, PLUMBING, AND ELECTRICAL CODES
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated building, plumbing, and electrical codes. The student should also be able to list members of a plumbing code governing board, match statements on building and plumbing codes, and match statements applying to history, purpose, and scope of the National Electrical Code. This knowledge will be evidenced by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with building, plumbing, or electrical codes to the correct definition or description.
2. List three members of a plumbing code governing board.
3. Select statements on the benefits of building and plumbing codes.
4. List three major categories of a plumbing code.
5. Match statements to their proper applications on the history, purpose, and scope of the National Electrical Code.

BUILDING, PLUMBING, AND ELECTRICAL CODES
UNIT V

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheets.

   F. Assign the local Plumbing Code Handbook as a required reading.

   G. Invite local plumbing inspector to visit class.

   H. Invite local electrical inspector to visit class.

   I. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Plumbing Code Governing Board

      2. TM 2--Zoning Laws

      3. TM 3--Electrical Code

   D. Test

E. Answers to test

II. References:

A. Blankenbaker, E. Keith. Modern Plumbing. South Holland, IL: Goodheart-Willcox, 1978.

B. Manus, V. National Plumbing Code Illustrated. St. Petersburg, FL: Manus Publishing, 1973.

C. Plumbing Individualized Learning, Scarboro, Ontario: Ministry of Colleges and Universities, 1978.

D. National Electrical Code, National Fire Protection Association. 470 Atlantic Ave. Boston, Mass., 02210.

BUILDING, PLUMBING, AND ELECTRICAL CODES
UNIT V

INFORMATION SHEET

I. Terms and definitions

A. Building code--Set of rules governing the quality of construction in a community

B. Plumbing code--Set of rules governing the quality of plumbing installations

(NOTE: A plumbing code can be established at either the state or local level.)

C. Electrical code--Set of rules governing the quality of wiring installation

(NOTE: Electrical codes may be established at the state and/or local level.)

D. Plumbing inspector--Person authorized to inspect and approve or disaprove plumbing installations according to code specifications

E. Electrical inspector--Person authorized to inspect and approve or disaprove wiring installations according to the code having jurisdiction

F. Inspection--Checking to see if the work conforms to the code specifications

G. National Plumbing Code--Plumbing code adopted in 1955 and generally accepted as a basis for developing state and local plumbing codes through much of the country

(NOTE: This code is meant only to be a guideline for state and local codes.)

H. National Electrical Code--First published in 1897 and since generally accepted as a basis for developing state and local wiring codes through out the country

(NOTE: The National Code is purely advisory.)

I. License--Document stating that the holder has passed trade tests and has proven the ability to perform satisfactory work

J. Board of Health--Local board which generally regulates and enforces the plumbing code

K. State Board of Electrical Examiners--State board which would examine and issue licenses to individuals meeting time and testing requirements for a state license

L. Local authority--Governing body having jurisdiction at the local level

M. Master Electrician--Individual licensed to perform electrical wiring as required

N. Journeyman Electrician--Individual licensed to perform wiring task under supervision of a master electrician

II. Plumbing code governing board (Transparency 1)

A. Membership

1. Member of the city board of health

2. Chief plumbing inspector

3. One or more master plumbers

4. One or more journeyman plumbers

(NOTE: Boards may vary in the number of members, professional background of members, and the authority in the administration of the code.)

B. Administrative authority

1. State board

2. Local board

(NOTE: States vary in the administration of their individual codes, i.e., some states have one state code, other states permit each locality to administer code.)

III. Benefits of building codes and plumbing codes (Transparency 2)

A. Building codes

1. Determine the quality of construction in a community

2. Protect public health, safety, and quality of life in a community

(NOTE: Building codes vary as to industrial business and residential construction. They are administered by a chief building inspector whose staff studies plans, issue permits, inspects construction, and maintains records of current construction and past construction.)

B. Plumbing codes

1. Protect the health of the community

2. Regulate all construction whether industrial, business, or residential

3. Permit grievances or complaints by the plumbing contractor to be reviewed by the board of health or the court

(NOTE: Plumbing codes are usually administered by the community board of health and are enforceable by court action.)

IV. Major categories of a plumbing code

A. Basic principles upon which the local code is determined

B. Terms and definitions

C. Basic regulations

Examples: Quality of materials and workmanship, pitch of piping, distances between clean-outs

D. Type of materials and sizing

E. Types and quality of joints

F. Provisions for inspections and testing

V. The National Electrical Code

A. History

1. 1881 - the first proposal was made by the National Association of Fire Engineers

2. 1895 - the first recommended National Electrical Code was published by the National Board of Fire Underwriters

3. 1897 - National Electrical Code drafted

4. 1911 - The National Fire Protection Association assumed sponsorship and control

B. Purpose

1. Intended to give guidelines for proper installation of electrical wiring to safeguard personnel and property

2. To serve as a guide in:

    a) The absence of a state or local code

    b) Support of state or local codes

C. Scope

1. The code covers:

    a) Electrical wiring and equipment installation in or on public or private buildings or structures

    b) Conductors that connect the installation to a supply of electricity

D. Organizational structure

1. Sponsor

    a) National Fire Protection Association

2. Drafting and editing

    a) National Electrical Code Panel

3. Acceptance and governing body

    a) State Electrical Examining Boards

    b) Local authority having jurisdiction over licensing and inspection of electrical wiring and equipment installation

4. Enforcers of the code

    a) Chief electrical inspectors and staff

    b) Local inspectors

(NOTE: Large cities will usually have a chief electrical inspector, whereas, small cities and towns will have only one local inspector.)

5. Applicators
    a) Electrical contractors
    b) Master electricians
    c) Journeyman electricians

Plumbing Code Governing Board

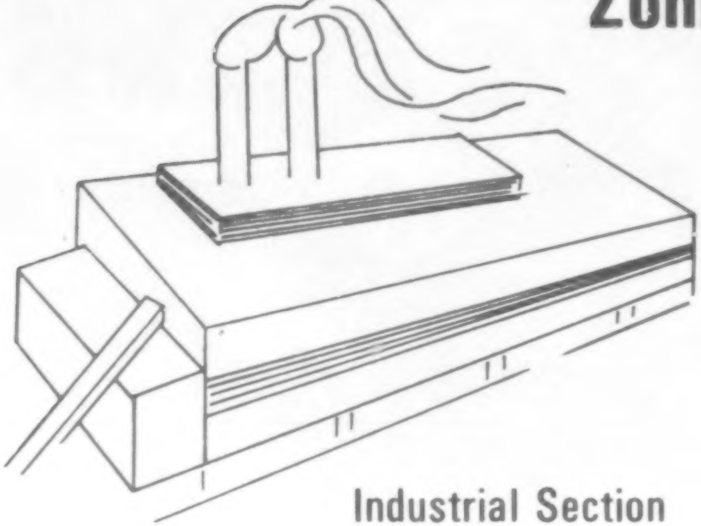
Member of
Board of Health

Chief Plumbing
Inspector

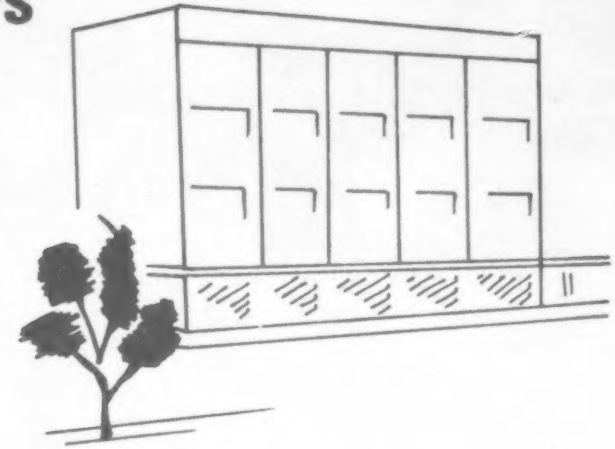
Master Plumber

Journeyman
Plumbers

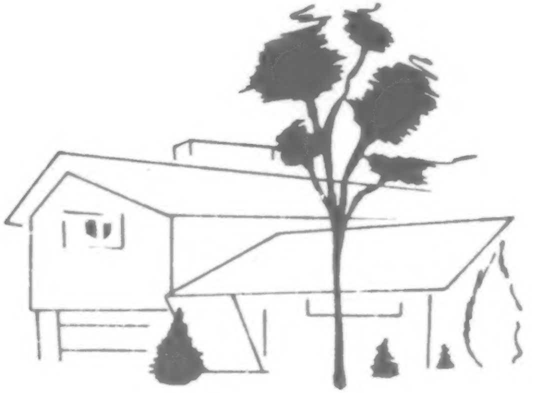
Zoning Laws



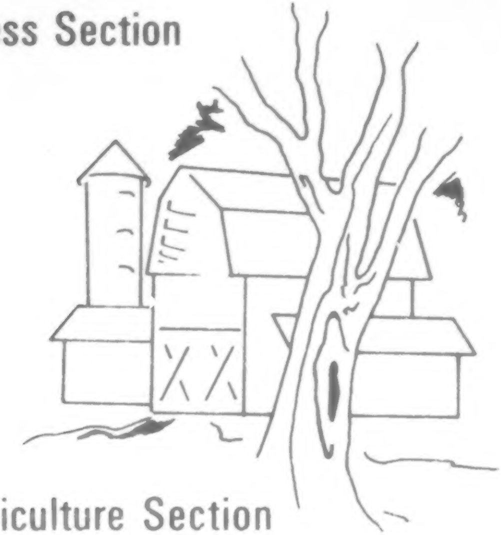
Industrial Section



Business Section



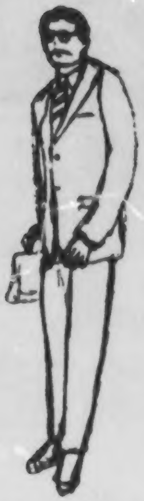
Residential Section



Agriculture Section

ELECTRICAL CODE

ACCEPTANCE, INSPECTION, AND APPLICATION



LOCAL AUTHORITY

ELECTRICAL INSPECTOR

ELECTRICAL CONTRACTOR

MASTER ELECTRICIAN

JOURNEYMAN ELECTRICIAN

TM-3

BUILDING, PLUMBING, AND ELECTRICAL CODES
UNIT V

NAME ______________________________

TEST

1. Match terms on the right to the correct definitions or descriptions.

_____ a. Set of rules governing the quality of construction in a community

_____ b. Set of rules governing the quality of plumbing installations

_____ c. Person authorized to inspect and approve or disapprove plumbing installations according to code specifications

_____ d. Rules which specify type of construction permitted in certain areas of a city or town

_____ e. Checking to see if the work conforms to the code specifications

_____ f. Plumbing code adopted in 1955 and generally accepted as basis for developing state and local codes through much of the country

_____ g. Document stating that the holder has passed trade tests and has proven ability to perform satisfactory work

_____ h. Local board which generally regulates and enforces the plumbing code

_____ i. Set of rules governing the quality of wiring installation

_____ j. Document generally accepted as a basis for developing state and local wiring codes

1. Plumbing code
2. Zoning laws
3. Inspection
4. License
5. Plumbing inspector
6. Board of Health
7. Building code
8. National Plumbing Code
9. Electrical inspector
10. Local authority
11. Electrical code
12. National Electrical Code
13. Journeyman electrician
14. Master electrician

_____k. Governing body having authority over code information

_____l. Individual licensed to perform electrical wiring under supervision of a master electrician

_____m. Person authorized to inspect and approve or disapprove electrical wiring installation according to applicable code specifications

_____n. Individual licensed to perform electrical wiring as required

2. List three members of a plumbing code governing board.

1. ____

2. ____

3. ____

3. Select statements on the benefits of building and plumbing codes by placing an "X" in the proper blanks.

a._____ Provides proper size wiring

b._____ Determines the quality of construction in a community

c._____ Provides an even number of plumbers on the state board

d._____ Regulates all construction, whether industrial, business, or residential

e._____ Protects public health, safety, and quality of life in a community

f._____ Permits grievances or complaints by the plumbing contractor to be reviewed by the State Board of Health or the court.

4. List three major categories of a plumbing code.

1. ____

2. ____

3. ____

5. Match the statements on the right to their proper applications on the history, purpose, and scope of the National Electrical Code.

A. History

1._____1881

2._____1897

3._____1911

B. Purpose

1._____

2._____

C. Scope

1._____

2._____

a. National Electrical Code drafted

b. The first proposal was made by the National Association of Fire Engineers

c. To serve as a guide in the absence of a state or local code

d. Conductors that connect the installation to a supply of electricity

e. Intended to give guidelines for proper installation of electrical wiring

f. Covers electrical wiring and equipment installation in or on public or private buildings or structures

g. The National Fire Protection Association assumed sponsorship and control

BUILDING, PLUMBING, AND ELECTRICAL CODES
UNIT V

ANSWERS TO TEST

1.
   a. 7
   b. 1
   c. 5
   d. 2
   e. 3
   f. 8
   g. 4
   h. 6
   i. 11
   j. 12
   k. 10
   l. 13
   m. 9
   n. 14

2. Any three of the following:
   a. Member of the city board of health
   b. Chief plumbing inspector
   c. One or more master plumbers
   d. One or more journeyman plumbers

3. b, d, e, f

4. Any three of the following:
   a. Basic principles upon which the local code is determined
   b. Terms and definitions
   c. Basic regulations

      Examples: Quality of materials and workmanship, pitch of piping, distances between clean-outs

   d. Type of materials and sizing
   e. Types and quality of joints
   f. Provisions for inspections and testing

5.
   A.
      1. b
      2. a
      3. g
   B.
      1. c
      2. e
   C.
      1. f
      2. d

APPLYING FOR A JOB
UNIT VI

UNIT OBJECTIVE

After completion of this unit, the student should be able to locate a job opening, make a formal application, and effectively interview for a job. This knowledge will be evidenced by correctly performing the procedures outlined on the assignment sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with applying for a job to the correct definitions.
2. List four means of locating job openings.
3. List three methods of applying for a job.
4. Select personal attributes or attitudes an employer looks for during a personal interview.
5. Select guidelines for dressing for an interview.
6. List four items which an applicant may need to prepare when applying for a job.
7. Select guidelines to follow when participating in a job interview.
8. Demonstrate the ability to:
    - A. Write a resume
    - B. Write a letter of application for a solar technician's job.
    - C. Complete employment application form for a job as a solar technician
    - D. Practice interview questions.
    - E. Make an appointment by phone for a job interview

F. Write a follow-up letter or make a follow-up phone call after interviewing for a job.

G. Evaluate a technician's job offer.

H. Compare job opportunities.

APPLYING FOR A JOB
UNIT VI

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide students with objective sheet.

   B. Provide students with information and assignment sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Invite resource person to discuss "What I look for on application letters, resumes, employment application forms, and follow-up devices" and "How do equal opportunity and affirmative action affect my hiring procedures?"

   G. Obtain actual letters of application and resumes to show to students.

   H. Give test.

II. Students:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete assignment sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

A. Objective sheet

B. Information sheet

C. Transparency masters

1. TM 1--Attitudes
2. TM 2--Appropriate Dress
3. TM 3--Take Time to be on Time

D. Assignment sheets

1. Assignment Sheet #1--Write a Resume
2. Assignment Sheet #2--Write a Letter of Application for a solar technician's job
3. Assignment Sheet #3--Complete Employment Application Form for a Job as a solar technician
4. Assignment Sheet #4--Practice Interview Questions
5. Assignment Sheet #5--Make an Appointment by Phone for a Job Interview
6. Assignment Sheet #6--Write a Follow-up Letter or Make a Follow-up Phone Call After Interviewing for a Job
7. Assignment Sheet #7--Evaluate a Technician's Job Offer
8. Assignment Sheet #8--Compare Job Opportunities

E. Test

F. Answers to test

III. Unit references:

A. Blackledge, Ethel H.; Blackledge, Walter L.; and Helen J. Keily. You and Your Job. Dallas: South-Western Publishing Company, 1967.

B. Milburn, Paul M. How to Get a Job. Shawnee, Oklahoma: Gordon Cooper Area Vocational Technical School, 1967.

C. Moynihan, Moynihan, and Daeger. You and Your Job--How to Get It. Chicago: J. G. Ferguson Publishing Company, 1968.

D. Wood, Merle W., and McKeena, Margaret. The Receptionist. Dallas: McGraw-Hill Book Company/ Gregg Division, 1966.

E. Can I Get the Job? Detroit: General Motors Public Relations Staff, 1972.

F. Keeton, Marsha. Job Application and Interview. University of Kentucky: Vocational Education Curriculum Development Center of Kentucky,1973.

G. Interviewing Women Candidates. Washington, D. C.: U. S. Civil Service Commission, 1974.

H. Your Attitude Is Showing. Austin, Texas: Instructional Materials, Division of Extension/ University of Texas, 1972.

I. Allen, Cliff. "About Getting a Job" and "After High School--What?" Practical Family Life. Greenfield, Mass.: Channing L. Bete, Inc., 1977.

J. Kimbrell, Grady, and Vineyard, Ben S. Succeeding in the World of Work. Bloomington, Illinois: McKnight Publishing Company, 1975.

K. Feingold,S. Norman, and Swerdloff, Sol. Occupations and Careers. St. Louis: McGraw-Hill Book Company/Webster Division, 1969.

APPLYING FOR A JOB
UNIT VI

INFORMATION SHEET

I. Terms and definitions

  A. Award--Recognition received for outstanding achievement

  B. Extracurricular activities--Clubs, organizations, and social or church groups in which one participates

  C. Fringe benefits--Extras provided by an employer, such as paid vacations, sick leave, and insurance protection

  D. Qualifications--Experience, education, and physical characteristics which suit a person to a job

  E. Resume--Brief, typed summary of one's qualifications and experience that is used in applying for a job

  F. Vocational preparation--Any vocational courses and skills one has learned in high school or through work experience

  G. Interview--Meeting of employer and job applicant for purpose of evaluation and questioning

  H. Application form--Printed form on which job applicants record information about their personal history, job history, job experience, education, and references

  I. Blind ad--Classified advertising that does not identify the advertiser

     (NOTE: Applicant is asked to send a letter of application and resume to a post office box number or to call a certain number.)

  J. Help wanted ad--Classified advertisement telling what kind of job is available and what the qualifications are

  K. Employment/situation wanted ad--Classified advertisement placed by individuals seeking employment and telling what their qualifications are

L. Employment agency--Business that is designed to help individuals find employment

M. Garnishee--To attach wages or other property to satisfy a debt

N. Legible--Capable of being read; clear

O. Equal opportunity employer--Employer who is making a special effort to assure that no form of discrimination is practiced

Examples: Age, sex, race, creed

II. Means of locating job openings

A. Classified ads

1. Newspapers

2. Magazines

B. Employment offices

1. Department of Labor

2. Private

(NOTE: A fee is charged by most private agencies.)

C. Local labor union business office

D. School officials

1. Teacher

2. Counselor

III. Methods of applying for a job

A. Letter

B. Telephone

C. In person

IV. Personal attributes or attitudes an employer looks for during a personal interview (Transparency 1)

A. Enthusiasm and interest

B. Dedication and dependability

C. Alertness, quickness of mind

- D. Honesty and integrity
- E. Desire to work
- F. Desire to help others
- G. Desire to improve one's self

V. Guidelines for dressing for an interview (Transparency 2)

- A. Job-related guidelines
  - 1. Kind of job

    (NOTE: A "rule of thumb" for any job interview is to dress better for the interview than you would for a day on the job.)

  - 2. Salary range
- B. Personal guidelines
  - 1. Coordinate clothing
  - 2. Be conservative
  - 3. Be modest and well-groomed

VI. Items which applicant may need to prepare when applying for a job (Assignment Sheets #1, #2, #3, #6)

- A. Resume
- B. Letter of application
- C. Application form
- D. Follow-up letter

VII. Guidelines to follow when participating in a job interview (Transparency 3)

- A. Preparing for the interview
  - 1. Be clean
  - 2. Be well-groomed and neat
  - 3. Wear appropriate clothes and shoes for the type of job
  - 4. Take an ink pen and resume with the information you may need about social security number, references, names and addresses, dates employed, and dates attended school

5. Go alone; do not take parents or friends

6. Do not be late; allow enough time

7. Find out facts about the interviewer ahead of time

    a. Name

        (NOTE: Make sure you have the correct pronunciation.)

    b. Title

8. Know facts about the business

    a. Name

    b. Kind of business

    c. Products and services

    d. Reasons you want to work there

    e. How old the company is and where the plants, offices, or stores are located

B. Metting the receptionist/secretary

1. Smile

2. Introduce yourself, stating that you have an appointment

    Example: "Good morning. I am Terry McKracken and am applying for a job as a technician. I have a 10:00 appointment with Mr. Smith."

3. Follow receptionist's/secretary's instructions

4. Wait patiently

C. Starting the interview

1. Smile

2. Listen

3. Enter with poise

4. Greet the interviewer by name

5. Shake hands firmly

6. Introduce yourself

7. State purpose of call
8. Be seated only at interviewer's invitation
9. Do not show signs of nervousness

   (NOTE: If you do not know where to put your hands, leave them on your lap and keep them still.)

10. Do not place personal things on interviewer's desk
11. Do not smoke or chew gum
12. Look alert; look interested and enthusiastic

    (NOTE: Sit slightly forward in chair to give an alert appearance.)

13. Be confident
14. Be courteous

    (NOTE: Words such as Mr., Mrs., Miss, thank you, please, and sir never go out of style.)

D. Answering questions clearly

1. Do not interrupt
2. Anticipate questions that might be asked and volunteer proper information
   - a. Explain yes and no answers
   - b. Avoid criticisms of former employers or competitors
   - c. Do not talk about personal problems
   - d. Show copies of your work if applicable
   - e. Answer all questions honestly

     Examples: "The thing I liked least about my last job was that I was on the night shift and couldn't get changed. I really wanted to be home with my family at night."

     "Truthfully, my relationship with my supervisor could have been better. We seemed to have a personality conflict and never became fond of each other. However, we did manage to work together. This was my first experience like that and I surely hope it doesn't happen again."

f. Give positive answers to unfavorable questions

Examples: Interviewer: "Your work experience doesn't seem to relate specifically to this job. Why do you feel qualified to fill this position?"

Applicant: "I understand your concern. However, my job experience is broad enough to permit me to work into this particular situation. I have done work similar to this job and I think my general work record is good. I would be willing to receive additional training."

g. Find a true, positive statement about your reasons for leaving previous jobs, even if you were fired

Examples: "I was laid off, but I learned from my mistakes."

"I left because they did not need as many employees during the slow season."

h. Try to mention your best qualities in relation to something concrete

Example: "I earned 75 percent of my expenses while going to school" is better than "I am a hard worker and want to get ahead"

i. Be prepared for personal questions about your home life and parents' occupations

j. Avoid questions concerning politics, economics, religion, and other controversial subjects

k. Answer questions about career objectives using specific terms about what you would like to do in the near future in that particular field without limiting your opportunities

   Example: A position that will lead to a supervisory position. No locational preference.

3. Look directly at interviewer

4. Speak in clear, moderate tones

5. Use correct English

   (NOTE: Avoid swearing, slang terms, or annoying phrases like "yea," "you know," or " uh-huh.")

6. Show interest in the business; ask questions

   Example: Incorrect: "Listen, I need to know if you have any benefits."

   Incorrect: "Now that you've questioned me, there are a few things that I want to know before I decide if I want to work for you."

   Correct: "I wonder if you could give me some information about the benefits available to employees?"

7. Sell yourself

   (NOTE: Never refer to yourself as just average or fair. Always look for a positive response.)

8. Do not get flustered

9. Give the interviewer the opportunity to mention salary and fringe benefits

E. Closing the interview

   1. Watch for sighn that the interview is over, such as the interviewer shuffling papers and moving around in chair

   2. Ask "May I say one thing more?" or "Would you be interested in. . .?" if the interview seems to be ending before all important selling points have been made

   3. Thank interviewer for his/her time

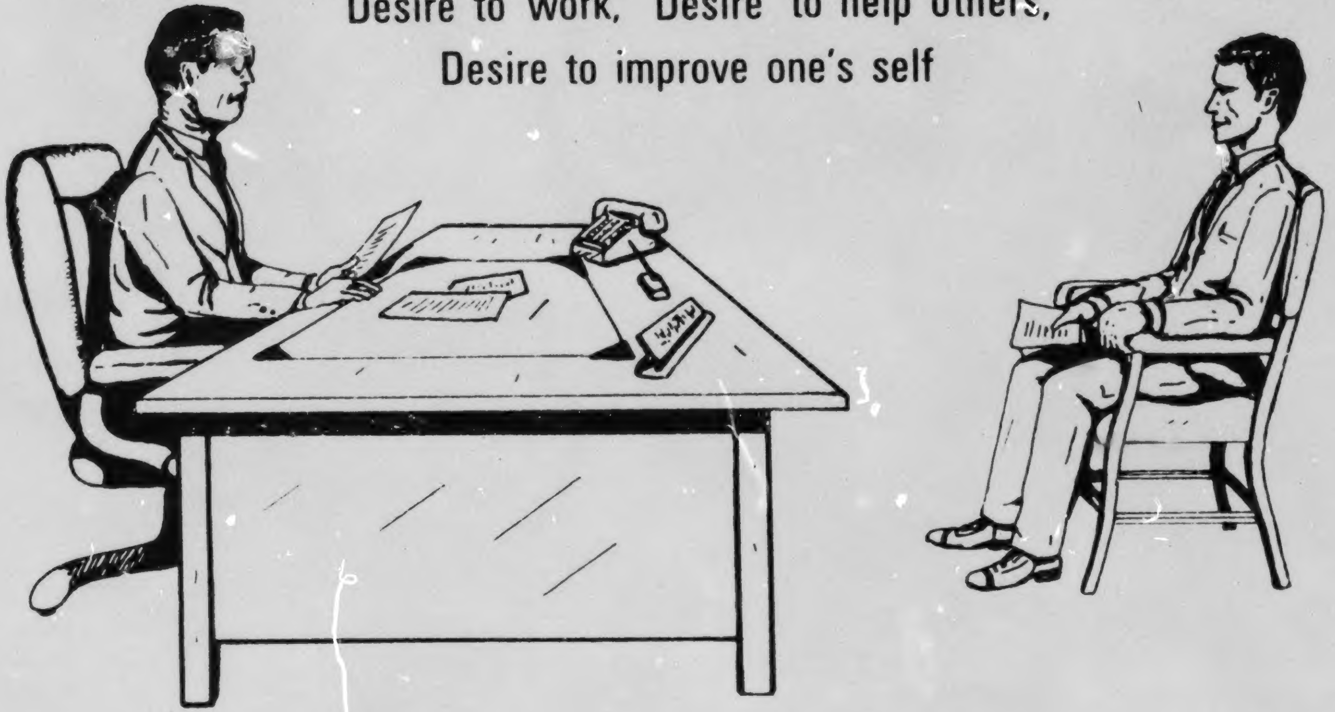
Example: "I've enjoyed talking to you, Mr. Smith. Thank you for your time and consideration. I'm excited about this job and do hope I'm hired. Can you tell me when the position will be filled and how the applicants will be notified? (Answer) Please let me know if you need any additional information."

4. Learn from every situation even if the interviewer does not offer the position

F. Following up the interview--Write thank you letter, call, or visit again to express interest in the job and appreciation for the opportunity to interview

Attitudes

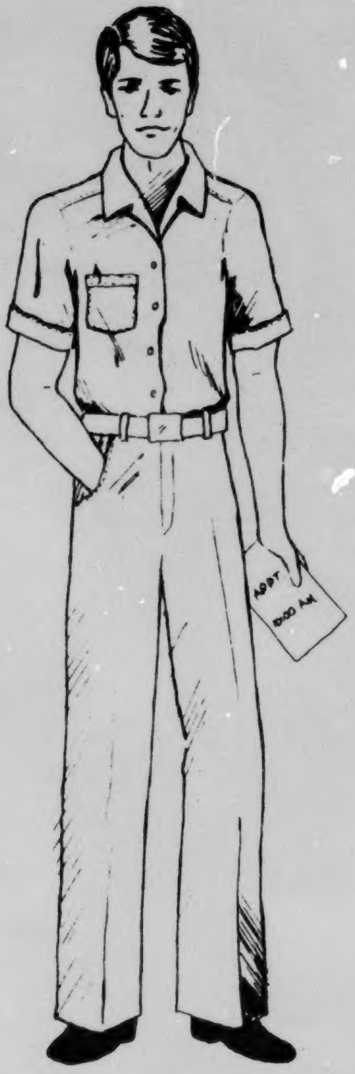
Enthusiasm, Interest, Dedication, Dependability, Alertness, Quickness of mind, Honesty, Integrity, Desire to work, Desire to help others, Desire to improve one's self



TM 1

S 113A

Appropriate Dress



Hair neat?

Friendly?

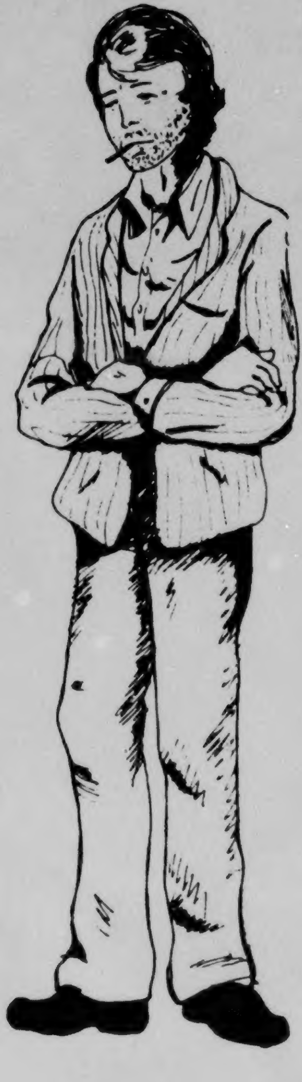
Clean Shaven?

Clean and neat clothes?

Pen and paper?

On time?

Shoes shined?



Take the Time to be on Time

TM 3

S 117A

APPLYING FOR A JOB
UNIT VI

ASSIGNMENT SHEET #1--WRITE A RESUME

Write a resume using accurate facts about yourself. Include the resume with a letter of application. Use the information below and the sample resume included in this assignment sheet as guides. A good resume should immediately give prospective employers a brief summary of your accomplishments, educational background, work experience, skills, and job objective. It is not necessary to use the exact wording and outline form used on the sample resume, but it is necessary that your resume be neat and balanced and contain all the information which might help you get a job. Keep a current copy of the resume and use it to apply for jobs.

1. Inspect several resume formats and choose one that best fits your needs or use the example included in this assignment sheet as a guide.
2. Type your resume on 8 1/2 x 11 inch white paper. Try not to exceed one page but attempt to fill the page.
3. Spell correctly. Many employers will not consider persons who have resumes that include misspelled words.
4. Put your name prominently at the top in the center or upper left-hand corner. Beneath name, give full street address, city, state, zip code, telephone number with area code, and a number where messages can be accepted.
5. Do not include birthplace, age, health, height, weight, sex, marital status, photo, salary, or reasons for leaving previous job. Avoid religious and political affiliations.

   (NOTE: In general, the more information you are willing to share the better. However, the whole point of the resume is to get employers interested to meet you in person. The above information may or may not come out in the interview. By not including this information there is little or no chance for discrimination because of race, color, religion, sex, or national origin.)

6. Describe your job objective or career goal briefly. Don't restrict yourself to a specific job unless you are experienced.

7. Describe your educational background, giving dates of enrollment, diploma or degrees received, and names of schools attended. Include grade average (if favorable) and major course of study. If you include school grades, be sure they are related to the jobs you have in mind.

   (NOTE: Applicants with less than one year of work experience should list education before work experience; with more than one year, put experience first. IN RESUME WRITING, ACCENTUATE THE POSITIVE, ELIMINATE THE NEGATIVE. If pertinent, mention additional courses, scholarships, or summer school.)

8. List your past employment, starting with your most recent job. Carefully examine all your jobs--including extracurricular activities. CONCENTRATE ON THE SKILLS; DON'T CATEGORIZE "SUMMER JOBS."

   (NOTE: The list should include the name of the company, your job title, and your major duties. The starting and termination dates for each job should be listed. Most employers ask during interviews why you left previous jobs. Try to be positive in stating your reasons for leaving a former job. Do not downgrade your previous employers.)

9. List skills useful to the job. Remember, you have to prove your value to the business, especially if you have little experience.

   (NOTE: Use active verbs to indicate the specific tasks you performed, e.g., built, assisted, operated.)

10. Include the following information if it is relevant and if there is enough space: hobbies and interests, extracurricular activities, clubs, awards you have received.

11. Ask at least three persons for recommendations; ask yourself the kinds of recommendations they will give you

    Examples: Business references, teachers,
    character references

    (NOTE: Avoid listing relatives unless you have actually worked for them on a salary basis. Include some method for prospective employer to acquire references.)

12. Write "Confidential" at the top of the resume if you don't want your current employer to know you're looking for employment.

13. Have local printer retype your resume and reproduce several copies. Request white bond paper.

    (NOTE: Your resume's physical appearance is VERY IMPORTANT. Avoid using ditto or carbon copies. Be sure to proofread the printer's work. Always bring extra copies to interview. Leave one copy of resume with interviewer and use one as a reference when filling out the application form. You should also mail one resume with your letter of application.)

APPLYING FOR A JOB
UNIT VI

ASSIGNMENT SHEET #2--WRITE A LETTER OF APPLICATION FOR A SOLAR TECHNICIAN'S JOB

The application letter is a sales technique to tell the employer how your abilities will be useful to the business. The letter should specify your qualifications while the resume gives general background information.

Cut a help-wanted ad for a technician's job from the classified ad section of the local paper. Write an application letter to accompany the resume you prepared in Assignment Sheet #1. Use the following information and the sample letter as a guide.

(NOTE: If you cannot type, it is recommended that you write or print NEATLY using blue or black ink.)

1. Use acceptable form and appearance
    a. Type or write neatly
    b. Write on only oneside of the paper
    c. Avoid smudges and typographical errors
    d. Use 8 1/2" x 11" white bond paper, not personal or fancy paper
    e. Spell, capitalize, and punctuate correctly
    f. Put employer's full name, title, and address
    g. Include your full name and address with zip code on the letter
    h. Retain a copy for further reference
2. Include proper information
    a. Write to a specific person

        (NOTE: Find out the name of the personnel manager/employer you want to reach and the correct title. When in doubt, write to the top person who will refer your resume to the right party. Use To Whom It May Concern if answering a blind ad.)

b. Avoid excessive use of the pronoun "I"

c. Be brief; do not repeat information in the resume

   1) State the position for which you are applying

   2) Avoid needless details

   3) Cover all points requested in the advertisement in exactly the order in which they were asked

      (NOTE: Some prospective employers make it a point of testing the applicant's ability to follow directions.)

d. State reason for interest in job

   (NOTE: Employers look for people who look for future advancement opportunities rather than just a paycheck.)

e. Refer briefly to the main points in the attached resume

f. Mention that persons listed on the resume have given their permission to serve as references

g. Request interview at employer's convenience

   1) Tell where you can be reached

   2) Enclose self-addressed envelope and resume

   3) Say you will phone next week

3. Be original in your approach--Attract attention in opening paragraph

Example:

Dear Mr. Money:

My experience as a technician would be of interest to you.

Dear Ms. Owner:

Mr. Co-worker informed me that you are in need of a person who can be a technician's helper. I believe that my experience and training have taught me how to handle these duties efficiently and accurately.

ASSIGNMENT SHEET #2

4. End the letter properly

   (NOTE: Sincerely yours or Very truly yours is appropriate.)

5. Use permanent address for the return address and make sure to include the current date

6. Staple letter to resume as it may be circulated to several departments and otherwise become detached

7. Follow up and phone for an appointment a week later

   (NOTE: Don't be surprised if the resume has been referred to another department. Remember, they are in business and you may not get immediate attention, especially if you sent a blind letter. Be persistent until you reach the right person and ask for a convenient date to set up an interview.)

8. Keep in touch regarding possible openings now and in the future

   (NOTE: The "job hunt" may take several weeks or even months! It's important to keep your contacts alive without being a nuisance.)

ASSIGNMENT SHEET #2

SAMPLE LETTER OF APPLICATION

Route #3
Anytown, Yourstate 77702
June 15, 1981

Mr. John Jones
Personnel Director
Uptown Solar Inc.
Box 19
Yourtown, Yourstate 77704

Dear Mr. Jones:

Please consider me for the solar technician's job that you advertised in the Daily Chronicle.

From the enclosed resume you may note that I shall graduate from Progress Vo-Tech School in June. In addition to my training, which included all phases of piping, electricity, motors and controls, soldering and welding, and solar hot-water systems, I worked for Jones Solar Shop during the summer of 1979. During this period I began to understand and appreciate the principles I learned in school as we installed and serviced different types of hotwater systems.

Solar energy does have an exciting future and I want to be part of this challenging and growing field.

I would appreciate the opportunity to have an interview with you at your convenience. I can be reached by telephone at 405-235-4433 after 3:30 or at the above address.

Sincerely yours,

Terry McKracken
Encl.

RESUME of TERRY McKRACKEN

Personal Data:

Address:	Route #3 Anytown, Yourstate 77704
Telephone:	405-235-4433
Date of Birth:	10-15-1960
Marital Status:	Single
Physical Condition:	Excellent (5'11", 185 lbs.)

Education and Training:

Progress Vo-Tech School Hwy 64 West Progressville, Anystate 72482	Graduate Solar Energy Technology June 1980
Anytown High School Anytown, Anystate 72401	Honor Graduate May, 1978

Work Experience:

Employer:	Jones Solar Shop Anytown, Anystate 72401
Date:	Summer 1979
Duties:	Installation and service of all phases of hotwater systems

Extracurricular Acitivities:

Nat'l Solar Technicians Cont. (3)
State Solar Technicians Cont. (1)
Baptist Youth Fellowship (Treas.)

VICA, President
Sr. Class, President

References: (with permission)

Sammy Slavedriver, Solar Instr.
Progress Vo-Tech School
Progressville, Anystate 72401
Phone: (501)358-4431

Mrs. Jerri Smith Youth Dir.
Parkview Baptist Church
711 Fellowship Circle
Anytown, Yourstate 77702
Phone: (501)287-6584

John Naildriver, Installation Supv.
Jones Solar Shop
Anytown, Anystate 72401
Phone: (501)483-3400

S.L. Lawson, Student Advisor
Progress Vo-Tech School
Progressville, anystate 72401
Phone: (501)358-4432

APPLYING FOR A JOB
UNIT VI

ASSIGNMENT SHEET #3--COMPLETE EMPLOYMENT APPLICATION FORM FOR A JOB AS A SOLAR TECHNICIAN

Complete the following application form using the guidelines below. Use information corresponding to the classified ad and to your letter of application. Use information about yourself from your resume.

(NOTE: Although each business uses its own form, general rules of preparation apply to any form.)

1. Be prepared
    a. Take a good ink pen with you
    b. Take copies of resume
2. Look over entire form before starting to write; do not hurry
3. Follow directions
    a. Note whether information is to be printed or handwritten
    b. Carry out all directions
4. Write clearly, neatly, and legibly
5. Answer briefly
6. Be honest
7. Answer all questions

    (NOTE: If questions do not apply to you, write Not Applicable or NA in the space to show that you did not overlook the question.)
8. Include complete information; use resume
9. Recheck application when finished
10. Avoid cross-outs and obvious erasure marks
11. Do not list any restrictions to the geographical area in which you would work unless you absolutely will not consider other geographical areas

12. Use the word "open" for questions about minimum salary since most employers pay standardized rates and will not negotiate on this

S 133A

"WE ARE AN EQUAL OPPORTUNITY EMPLOYMENT COMPANY. WE ARE DEDICATED TO A POLICY OF NON-DISCRIMINATION IN EMPLOYMENT ON ANY BASIS INCLUDING RACE, CREED, COLOR, AGE, SEX, RELIGION OR NATIONAL ORIGIN OR PHYSICAL DEFECTS."

APPLICATION FOR EMPLOYMENT

PERSONAL INFORMATION

Date

Name
Last First Middle

Present Address
Street City State Zip

Permanent Address
Street City State Zip

Phone No. Social Security Number

Referred By

EMPLOYMENT DESIRED

Position Date You Can Start Salary Desired

Are You Employed Now? If so, may we inquire of your present employer

Ever applied to this company before? Where When

EDUCATION	Name and location of school	Years Attended	Date Graduated	Subjects Studied
Grammar School				
High School				
College				
Trade, business, or correspondence school				

S 135A

Subjects of special study or research work

U.S. military or naval service Rank Present Membership in national guard or reserves

Activities other than religious (civic, athletic, fraternal, etc.) Include organizations, the name or character of which indicates the race, creed, color, or national origin of its members.

FORMER EMPLOYERS (list below last four employers, starting with last one first.)

Date Month & Year	Name and address of employer	Salary	Position	Reason for Leaving
From To				
From To				
From To				
From To				

REFERENCES: Give below the names of two persons not related to you, whom you have known at least one year.

	Name	Address	Business	Years Acquainted
1				
2				

PHYSICAL RECORD:

List any physical defects

Were you ever injured? Give details

Have you any defects in hearing? In vision? In speech?

In case of emergency notify

Name Address Phone No.

S 137A

I authorize investigation of all statements contained in this application. I understand that misrepresentation or omission of facts called for is cause for dismissal. Further, I understand and agree that my employment is for no definite period and may, regardless of the date of the date of payment of my wages and salary, be terminated at any time without any previous notice

Date Signature

DO NOT WRITE BELOW THIS LINE

TO BE COMPLETED DAY EMPLOYMENT BEGINS Date

Height Weight Age Date of birth

Single Married Widowed Citizen U.S.A. Sex

The above information needed for pension, hospitalization, insurance, etc., and not for hiring purposes

Interviewed by Date Remarks

Neatness Character

Personality Ability

Hired For Dept. Position will report Salary wages

Approved: 1. Employment Manager 2. Dept. Head 3. General Manager

APPLYING FOR A JOB
UNIT VI

ASSIGNMENT SHEET #4--PRACTICE INTERVIEW QUESTIONS

The following are some additional questions which might be asked when applying for various jobs. Keep the assignment sheet to review before going on any actual interview.

(NOTE: Questions about your personal life may not legally be asked. In fact, it is illegal for an employer to ask your maiden name or your father's surname if you are a female applicant; your marital status; who lives with you; the church you attend or the name of your spiritual leader; how many children you have, their ages, or who will care for them while you are at work; whether you own or rent your residence; whether you have ever had your wages garnisheed; and whether you have ever been arrested. However, many interviewers, particularly in smaller businesses, may ask such questions. Whether or not you chose to answer the questions depends on how badly you want the job.)

How would you answer the following questions? Why do you think each question might be asked?

1. Where do you go to school? When will you graduate?
2. Do you (did you) earn any of your own expense money while in school?
3. Why did you leave your previous job(s)?
4. What did you like best and what did you like least about your classes?

   (NOTE: This could be asked about teachers, jobs, or employers.)
5. What books have you read lately? What are your favorite magazines?
6. Are you in good health?
7. What do you expect to be doing five or ten years from now? What is your chosen field of work?
8. At what salary do you expect to start?
9. What are some of your special abilities? What skills do you possess? What tools or equipment can you operate?

10. How would you rate your training for this job? Very good? Fair?

11. What personal characteristics do you think are needed to succeed in your vocation?

12. In what area do you need the most improvement?

13. Do you like to work with other people or do you work best alone?

14. Do you have any questions you want to ask us?

15. Do you think your extracurricular activities were worth the time you devoted to them?

16. How could you contribute to our organization? Why should we hire you?

17. Tell us about your family and any plans for marriage or further education.

    (NOTE: REMEMBER: Legally, you do not have to answer this question. However, it is a good idea to prepare an answer in case such a question is asked.)

18. For what other jobs have you applied?

19. Do you have any military obligations to fulfill?

20. Give us an example of a project you finished under pressure.

21. May we write or call your last employer?

22. How many people have you supervised at work or through organizations of which you are a member?

23. How do you feel about the progress you have made salary-wise?

24. Would you be able to work all day Saturday and Sunday?

25. If you could start school (or work) over again what would you do differently?

26. What is your school attendance record?

27. Have you done the best school work of which you are capable?

28. Do you require attention? Does criticism disturb you?

    (NOTE: These questions are usually asked in a more subtle and indirect way.)

29. What motivates you?

30. Would you be willing to relocate?

31. What size city do you prefer?

32. Have you saved any money?

33. Define cooperation.

34. What job with our company would you choose if you were entirely free to do so?

35. How do you feel about working overtime?

REMEMBER: YOU NEVER GET A SECOND CHANCE TO MAKE A GOOD FIRST IMPRESSION!!! GETTING A JOB IS A JOB!!!

APPLYING FOR A JOB
UNIT VI

ASSIGNMENT SHEET #6--WRITE A FOLLOW-UP LETTER OR MAKE A FOLLOW-UP PHONE CALL AFTER INTERVIEW FOR JOB

It is sometimes helpful to return to a business and check again on possible job openings. This is often done about a week after the first interview. This short casual visit accomplishes two things. It helps the interviewer remember you, and it shows that you have a sincere interest in working for that company.

However, it is not always possible to have this type of informal atmosphere when applying for a job. In which case, it is always proper to send a follow-up letter or make a follow-up telephone call.

PART A

Write a follow-up letter thanking the employer for the interview. Use any form you wish or follow the format of the sample follow-up letter included in the assignment sheet.

1. Make sure your letter meets the following standards
    a. Typed or written perfectly
    b. Clean, neat, and attractively arranged on the page
    c. Free from spelling, punctuation, and grammatical errors
    d. Sent within a day or two after the interview
2. Include the following points in your follow-up letter
    a. Expression of appreciation for interviewer's time and interest
    b. Summary of your qualifications and interest in position
    c. Your name, address, and phone number (to make it easier for your employer to contact you)

S 146A

ASSIGNMENT SHEET #6

3. Make this last bid for the job a prime example of your excellent work habits: make the letter clean, neat, and well-worded

4. Address a legal-sized envelope (Figure 1)

   (NOTE: Be sure and type the address EXACTLY the same as the inside address of the letter.)

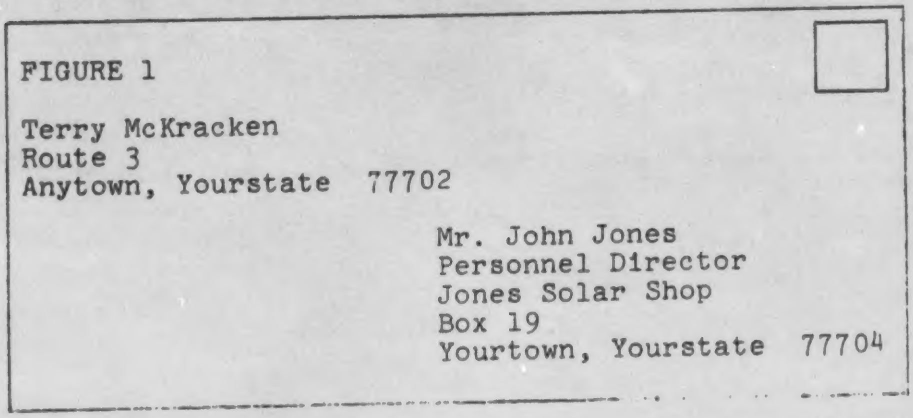


FIGURE 1

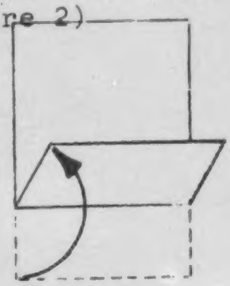
Terry McKracken
Route 3
Anytown, Yourstate 77702

Mr. John Jones
Personnel Director
Jones Solar Shop
Box 19
Yourtown, Yourstate 77704

5. Fold letter

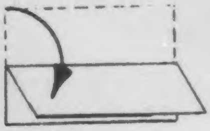
   a. Fold slightly less than one-third of the letter toward the top (Figure 2)

FIGURE 2



   b. Fold down the top of the letter to within 1 cm (1/2") of the bottom fold (Figure 3)

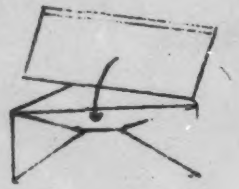
FIGURE 3



ASSIGNMENT SHEET #6

6. Insert the letter into the envelope with the last crease toward the bottom of the envelope (Figure 4)

FIGURE 4



PART B

Role play a follow-up telephone call using the guidelines below.

1. Make sure you include the following information
   - a. Your name
   - b. Date of your interview
   - c. Position for which you were interviewed
2. Ask whether a decision has been made

Example:	Incorrect:	"Hello, Mr. Jones. This is Terry McKracken. You told me you would let me know about the job, but I haven't heard anything from you. Why haven't you called me?"
	Incorrect:	"This is Terry McKracken. Did I get the job?"
	Correct:	"Hello, Mr. Jones. This is Terry McKracken. I interviewed with you on June 30th for the position of a solar technician. Have you made a decision on my application yet?"

3. If someone has already been hired, thank the interviewer for considering you but express continued interest in working for the company

Example:	Incorrect:	"Oh well, that's my luck. Thanks anyway."
	Incorrect:	"I didn't want to work for your company anyway."
	Correct:	"I am sorry I was not hired. Thank you for at least considering my application. I am still interested in working for the company and would appreciate you keeping my application on file."

ASSIGNMENT SHEET #6

SAMPLE FOLLOW-UP LETTER

Route #3
Anytown, Yourstate 77702
July 1, 1981

Mr. John Jones
Personnel Director
Uptown Solar Inc.
Box 19
Yourtown, Yourstate 77704

Dear Mr. Jones:

Thank you for interviewing me for the job of solar technician with your company. I feel that working for Uptown Solar Inc. would be enjoyable and that I could do the general installation and service work that the job requires. I hope that I will have the opportunity to prove my worth.

The application form you gave me is enclosed.

I will be available for work May 15. You may call me at my home after 3:30 p.m. The number is 405-235-4433.

Sincerely,

Terry McKracken

Encl.

APPLYING FOR A JOB
UNIT VI

ASSIGNMENT SHEET#7--EVALUATE A TECHNICIAN JOB OFFER

Instead of saying "yes" or "no" on the spot to a job offer, express your gratitude in a warm and friendly manner, and then ask if you may have time to consider the opportunity you have been offered. Few reputable employers will deny you a reasonable time to be certain before agreeing to take a job.

Avoid getting stuck with a job that's wrong for you by using the following checklist to evaluate the job offer.

THE JOB...

Do I clearly understand the nature of the work and is it what I want to do? Are my responsibilities reflected in the job title?

If this isn't my dream job, can it be a stepping stone as I acquire the skills and experience needed for advancement?

Is the background I'm building so narrow that I will have difficulty transferring it to another employer?

Will I be able to make any decisions affecting my work? Do I care?

Will I need more training and will the company pay for it?

Will overtime be necessary or available?

Will I be able to leave all thought of the job behind at day's end? If not, do I care?

Will I have to travel or relocate?

Is the job permanent or temporary?

If permanent, is there reasonable job security?

Does this job require union membership?

THE COMPANY...

Is the firm too large and heavy with rules for my personality?

Is the firm too small to offer room for advancement or impressive credentials for a future resume

Does the firm have a healthy financial position and is it a growing organization?

Is there a high turnover of personnel, and if so, why?

Does the firm promote from within the ranks or turn to outsiders to fill supervisory jobs?

Have I met the person who would be my immediate supervisor?

Does the supervisor seem like the sort of person with whom I could get along?

Do co-workers appear to be my kind of people?

Is the company's location convenient?

What is the firm's reputation for fair treatment of employees?

Is a written personnel statement available that covers vacations, sick leave, cause for dismissal, and so forth?

FINANCIAL REWARDS...

Do the earnings meet my minimum needs? Are there automatic cost-of-living increases?

What is the method of payment--salary, hourly wage?

Are raises based on merit, length of service, formal exams?

What fringe benefits are given--health insurance, free parking, discount privileges, and others?

WHEN TO SAY NO...Should you always turn down an offer that doesn't measure up?

ASSIGNMENT SHEET #7

That depends on several questions. How desperately do you need to earn money? How competitive is the field you hope to enter, and would it be best to get your foot in the door any way you can? How valuable is the experience you'll gain? There are times when it is wise to accept a job which is not perfect in your eyes.

On the other hand, it could be best to refuse the offer.

Adapted from "If Things Don't Shape Up, I May Not Take the Job," Career World, February, 1977.

APPLYING FOR A JOB
UNIT VI

ASSIGNMENT SHEET #8--COMPARE JOB OPPORTUNITIES

When you are offered a job or are changing jobs there are many factors to weigh before taking the position.

- What is your take-home pay?
- What are the benefits which accompany the job?
- How much will it cost to actually be at work each day?
- Would the job be satisfying to you?
- How would the job meet your needs and aspirations?

WHAT'S MY TAKE-HOME PAY?

Salaries and wages are often quoted by employers as gross earnings. Gross earnings are used because tax deductions vary due to the number of dependents, the amount of earnings, and other information.

Optional benefits and deductions offered by an employer also differ. It is generally advisable to ask what programs are available for enrollment as these can affect the actual money you receive on pay day.

ASSIGNMENT SHEET #8

WHAT OTHER BENEFITS DO I GET FROM THIS JOB?

Some benefits associated with working are not always visible. Often some of these overlooked benefits are paid for in part by your employer. At the time of the interview or when considering a position ask about:

- Employer's contributions for your protection which may include:
    - Health insurance
    - Unemployment compensation
    - Clothing and safety garments
    - Medical facilities and health tests
    - Pensions
    - Travel insurance (covering mishaps when traveling on business)
    - Educational programs or reimbursement for courses related to job
- Sick leave with pay
- Paid vacations and holidays

WHAT WILL IT COST TO WORK AT THIS JOB?

Frequently, we often overlook the costs which are associated with being employed. It may be of value to calculate estimated weekly expenses before you make a decision about a job.

Estimate weekly expenses for:

Transportation (parking, bus fares) $_____

Lunches (or cost of food eaten away from home, including soft drinks and coffee $_____

Clothing (including) $_____

Child care for working parent $_____

Gifts for other employees $_____

Special uniforms, materials, or equipment for job $_____

Other $_____

TOTAL $_____

ASSIGNMENT SHEET #8

WHAT IS IMPORTANT TO ME IN A JOB?

Take-home pay and benefits may be only part of what you want from a job. Think through other things you consider important in a job.

What are some of the most rewarding things you've felt about any job you've ever had?

1. ____
2. ____
3. ____

How might you rate these in order of what's important to you?

_____ Job security (little chance you'll be released from the job)

_____ Opportunity for advancement

_____ Recognition for your work

_____ Good wages

_____ Opportunity to learn and use your ideas

_____ Flexible working hours

_____ Long vacations

_____ Pleasant working conditions

_____ Interesting work

_____ Friendly co-workers

_____ Other, such as _______________________________

ARE YOU READY TO DECIDE????

Take all the information you have gathered and summarize it below and on the next page to reach a decision about whether you want the job or not.

1. Would the job be satisfying to you? Why/why not?

____

____

____

2. What are the benefits which accompany the job?

3. How much will it cost to actually be at work each day?

4. How would the job meet your needs and aspirations?

5. I estimate my take-home pay to be $__________.

6. I estimate my expenses related to working to be $__________.

7. I would most enjoy the following about this job: __________

8. I estimate my job benefits to be worth $__________?

APPLYING FOR A JOB
UNIT VI

NAME____________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Brief, typed summary of one's qualifications and experience that is used in applying for a job

_____b. Extras provided by an employer, such as paid vacations, sick leave, and insurance protection

_____c. Recognition received for outstanding achievement

_____d. Experience, education, and physical characteristics which suit a person to a job

_____e. Any vocational courses and skills one has learned in high school or through work experience

_____f. Clubs, organizations, and social or church groups in which one participates

_____g. To attach wages or other property

_____h. Meeting of employer and job applicant for purpose of evaluation and questioning

_____i. Printed form on which job applicants record information about their personal history, job history, job experience, education, and references

_____j. Business that is designed to help individuals find employment

_____k. Classified advertising that does not identify the advertiser

_____l. Classified advertisement placed by individuals seeking employment and telling what their qualifications are

1. Award
2. Interview
3. Extracurricular activities
4. Fringe benefits
5. Application form
6. Qualitications
7. Resume
8. Garnishee
9. Vocational preparation
10. Employment agency
11. Equal opportunity employer
12. Blind ad
13. Help wanted ad
14. Legible
15. Employment/situation wanted ad

_____m. Classified advertisement telling what kind of job is available and what the qualifications are

_____n. Capable of being read; clear

_____o. Employer who is making a special effort to assure that no form of discrimination is practiced

2. List four means of locating job openings.

a.

b.

c.

d.

3. List three methods of applying for a job.

a.

b.

c.

4. Select personal attributes or attitudes an employer looks for during a personal interview by placing an "X" in the appropriate blanks.

_____a. Alertness, quickness of mind

_____b. Long wavy hair

_____c. Dedication and dependability

_____d. Enthusiasm and interest

_____e. New car

_____f. Honesty and integrity

_____g. Desire to work

_____h. Beard

_____i. Flashy clothes

_____j. Desire to help others

_____k. Desire to improve one's self

5. Select guidelines for dressing for an interview by placing an "X" in the appropriate blanks.

_____a. Kind of job

_____b. Salary range

_____c. What employer is wearing on the job

_____d. Age of the interviewer

_____e. Age of the interviewee

_____f. Wear highly fashionable clothing

_____g. Be modest and well-groomed

6. List four items which an applicant may need to prepare when applying for a job.

a.

b.

c.

d.

7. Select guidelines to follow when participating in a job interview by placing an "X" in the appropriate blanks.

_____a. Take parents or friends with you to job interview

_____b. Know facts about the business

_____c. Start the interview with a smile and greet the interviewer by name

_____d. Place personal things, such as coat, hat, or purse, on interviewer's desk

_____e. Criticize former employers or competitors when applicable

_____f. State that you are willing to start at the beginning salary

_____g. Answer all questions honestly

_____h. Ask questions about politics, economics, religion, and other controversial subjects

_____i. Look directly at interviewer

_____j. Do not ask questions or show interest in the business

_____k. Thank interviewer for his/her time

_____l. Write thank you letter, call, or visit again to express interest in the job and appreciation for the opportunity to interview

8. Demonstrate the ability to:

   A. Write a resume

   B. Write a letter of application for a solar technician's job

   C. Complete an employment application form for a job as a solar technician

   D. Practice interview questions

   E. Make an appointment by phone for a job interview

   F. Write a follow-up letter or make a follow-up phone call after an interview for a job

   G. Evaluate a technician's job offer

   H. Compare job opportunities

   (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

APPLYING FOR A JOB
UNIT VI

ANSWERS TO TEST

1. a. 7
   b. 4
   c. 1
   d. 6
   e. 9
   f. 3
   g. 8
   h. 2
   i. 5
   j. 10
   k. 12
   l. 15
   m. 13
   n. 14
   o. 11

2. Any four of the following:
   a. Classified ads
      1) Newspapers
      2) Magazines
   b. Employment offices
      1) Department of Labor
      2) Private
   c. Local labor union business office
   d. School officials
      1) Teacher
      2) Counselor

3. a. Letter
   b. Telephone
   c. In person

4. a, c, d, f, g, j, k

5. a, b, g

6. a. Resume

   b. Letter of application

   c. Application form

   d. Follow-up letter

7. b, c, g, i, k, l

8. Performance skills evaluated to the satisfaction of the instructor.

FUNDAMENTALS OF ELECTRICITY
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student will be expected to demonstrate the ability to match terms associated with electricity and circuits, distinguish between series, parallel and series-parallel circuits, use Ohms Law to calculate voltage, resistance and current, perform basic soldering skills and score 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with electricity to the correct definitions.
2. Distinguish between alternating and direct current.
3. List six good conductors of electricity.
4. List five good insulators of electricity.
5. List the symbols and equations for Ohms Law.
6. List four common wattage conversions.
7. List the four basic parts of a circuit.
8. Match terms to correct electrical symbols.
9. Distinguish between a series, parallel and series-parallel circuits.
10. List four rules for a series circuit.
11. List three rules for a parallel circuit.
12. Match amperage loads to correct wire size.
13. Demonstrate the ability to:
    a. Use Ohms Law
    b. Select parallel loads
    c. Solder electrical wire joints

FUNDAMENTALS OF ELECTRICITY
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information, assignment, and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information, aassignment, and job sheets.

   F. Show students charts, films, and other supplementary materials on electrical fundamentals.

   G. Show students how to calculate problems.

   H. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete assignment and job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet.

   B. Information sheet.

   C. Transparency masters.

      1. TM 1--Ohms Law Memory Aid

      2. TM 2--Basic Circuit

      3. TM 3--Symbols

    4. TM 4--Symbols (Continued)
    5. TM 5--Symbols (Continued)
    6. TM 6--Series Circuit
    7. TM 7--Parallel Circuit
    8. TM 8--Series-Parallel Circuit

D. Assignment Sheets

    1. Assignment sheet No. 1--Use Ohm's Law
    2. Assignment sheet No. 2--Selection of parallel loads

E. Answers to assignment sheets 1 and 2

F. Job sheet No.1--Solder electrical wire splice

G. Unit test

H. Answers to unit test

II. References:

A. Mileaf, Harry. Electricity One-Seven. New York, New York: Hayden Book Co. 1966.

FUNDAMENTALS OF ELECTRICITY
UNIT I

INFORMATION SHEET

I. Terms and Definitions

A. Voltage--Potential difference which causes current flow. (NOTE: also referred to as EMF)

B. Counter EMF--Voltage induced in a conductor which is in opposition to the source voltage. (NOTE: a generator action that is present in every motor)

C. Electrons--Negatively charged particles.

D. Current--Flow of electrons through a conductor measured in amperes.

E. Conductor--Any material with the ability to permit passage of electrical current.

F. Resistance--Opposition to current flow measured in Ohms.

G. Insulator--Material with a very high resistance to current flow.

H. Reactance--Property in an electrical circuit that opposes any change in the existing current.

I. Capacitance--Factor in an electrical circuit that allows for storage of electrical changes and opposes any change in existing voltage.

J. Impedance--Total opposition in an electrical circuit to the flow of alternating current.

K. Hertz--One complete reversal of an alternating current from positive to negative and back to zero in one second.
(NOTE: Hertz is often used instead of the word cycle)

L. Solid state--Electrical circuit containing semi-conductors.

M. Semi-conductors--Conductor which has a resistance valve between a good conductor and an insulator.

N. Series circuit--Current has only one path it can take.

O. Parallel circuit--Current has more than one path through which to flow.

P. Series-parallel circuit--Electrical circuit consisting of both series and parallel components.

Q. Branch--That portion of a total circuit which is independent of other portions with each receiving full supply voltage.

R. Low line voltage--Decrease in voltage available to a power consuming device.

S. Load--Power consuming device.

II. Types of Electricity

A. Direct Current

1. Supplied by

a. Generator

b. Battery

1) Dry cell

2) Wet cell

2. Flows in one direction only

3. Abbreviated as DC

B. Alternating current

1. Supplied by an alternating current generator (alternator)

2. Flows in one direction then reverses and flows in the opposite direction

3. Abbreviated as AC

III. Conductors of electricity

A. Silver
(NOTE: Silver has the least resistance to current flow.)

B. Copper

C. Gold

INFORMATION SHEET

- D. Aluminum
- E. Steel
- F. Lead
- G. Nichrome
- H. Mercury
- I. Iron
- J. Brass
- K. Tin
- L. Water
- M. Air
  (NOTE: (1) Air will conduct electricity under certain humidity conditions. (2) Water will conduct electricity when it contains certain minerals.)

IV. Insulators of Electricity

- A. Mica
- B. Rubber
- C. Glass
- D. Plastic
- E. Ceramic
- F. Wood

V. Ohm's Law

- A. Establishes a mathematical relationship between:
  - 1. Voltage (EMF, potential, etc.)
  - 2. Amperage (current flow, electron flow, etc.)
  - 3. Resistance (Ohms)
- B. Equation symbols
  - 1. E = Potential measured in volts

2. I = Current flow measured in amperes

3. R = Resistance measured in ohms

C. Equations (Transparency 1)

1. E = I x R

2. I = E/R

3. R = E/I

VI. Common conversions of wattage

A. 1,000 watts = 1 kilowatt (kw)

B. 1,000,000 watts = 1 megawatt

C. 746 watts = 1 horsepower (hp)

D. 1 watt-hour = 3.413 b.t.u.'s

VII. Basic parts of a complete electrical circuit (Transparency 2)

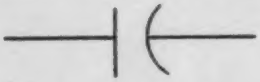
A. Power source

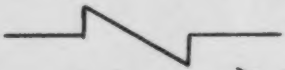
B. Connecting Wiring

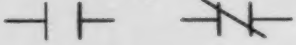
C. Load

D. Control Device

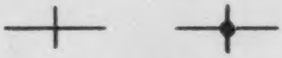
VIII. Electrical Symbols (Transparencies 3, 4, and 5)

A. Capacitor 

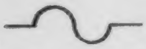
B. Coils 

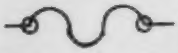
C. Contacts 

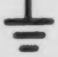
Normally Open (N.O.) Normally Closed (N.C.)

D. Conductors 

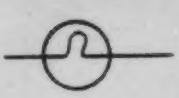
Crossing Junction

E. Fuse 

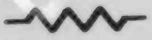
F. Fusible link 

G. Ground connection 

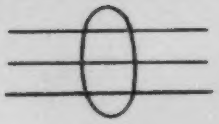
H. Light



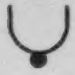
I. Resistor or resistance heater



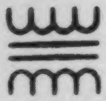
J. Multiple conductor cable



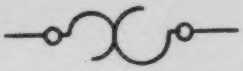
K. Thermocouple



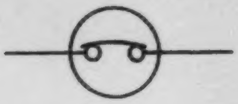
L. Transformer



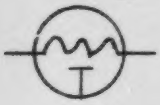
M. Thermal overload



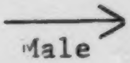
N. Bimetal switch



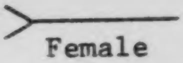
O. Thermistor



P. Connectors

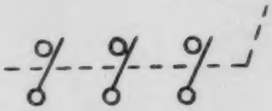


Male

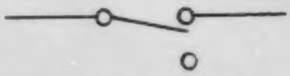


Female

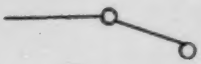
Q. Switches
disconnect



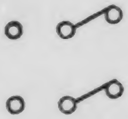
R. Single pole single throw (SPST)



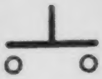
S. Single pole double throw (SPDT)



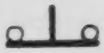
T. Double pole double throw (DPDT)



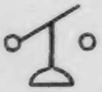
U. Push button (normally open)



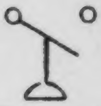
V. Push button (normally closed)



W. Pressure switches

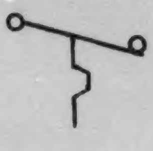


Opens on Pressure Rise

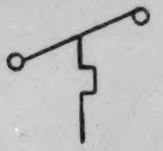


Opens on Pressure Drop

X. Temperature switch

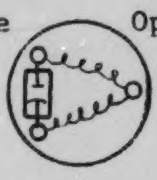


Close on Rise

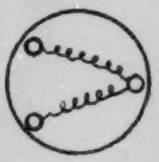


Open on Rise

Y. Permanent split capacitor motor



Z. Split-phase motor



IX. Series, parallel, and series-parallel circuits

A. Series circuit (Transparency 6)

B. Parallel circuit (Transparency 7)

C. Series-parallel circuit (Transparency 8)

X. Rules for series circuits

A. The current is the same throughout the circuit.

B. The sum of the voltage drops around a series circuit will equal the supply voltage.

C. The largest voltage drop occurs in the component with the highest resistance.

D. The sum of the resistances of the components equals the total resistance.

XI. Rules for parallel circuits

A. Total current equals the sum of the current in all branches.

B. Voltage is the same across all branches.

C. Total resistance is always less than the smallest branch resistance.

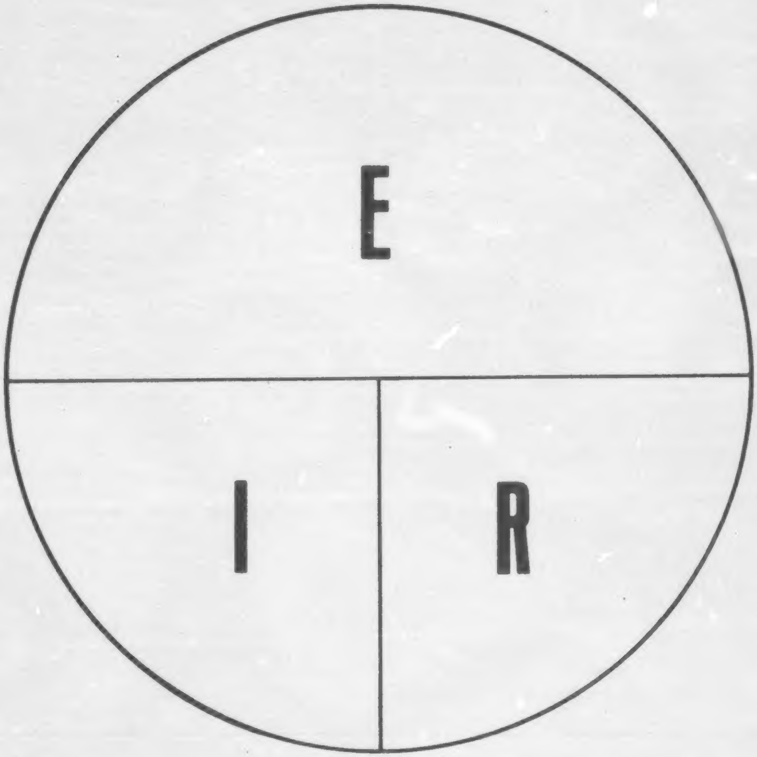
XII. Amperage loads and wire sizes

GENERAL PURPOSE

Wire Size AWG	Allowable Capacity Amps.	Maximum Motor Size Horse Power		
		Single Phase		3 Phase
		115V	230V	230V
14	15	3/4	2	3
12	20	1	3	5
10	30	2	3	7-1/2
8	40	3	5	10
6	55	3	7-1/2	15
4	70	5	10	20

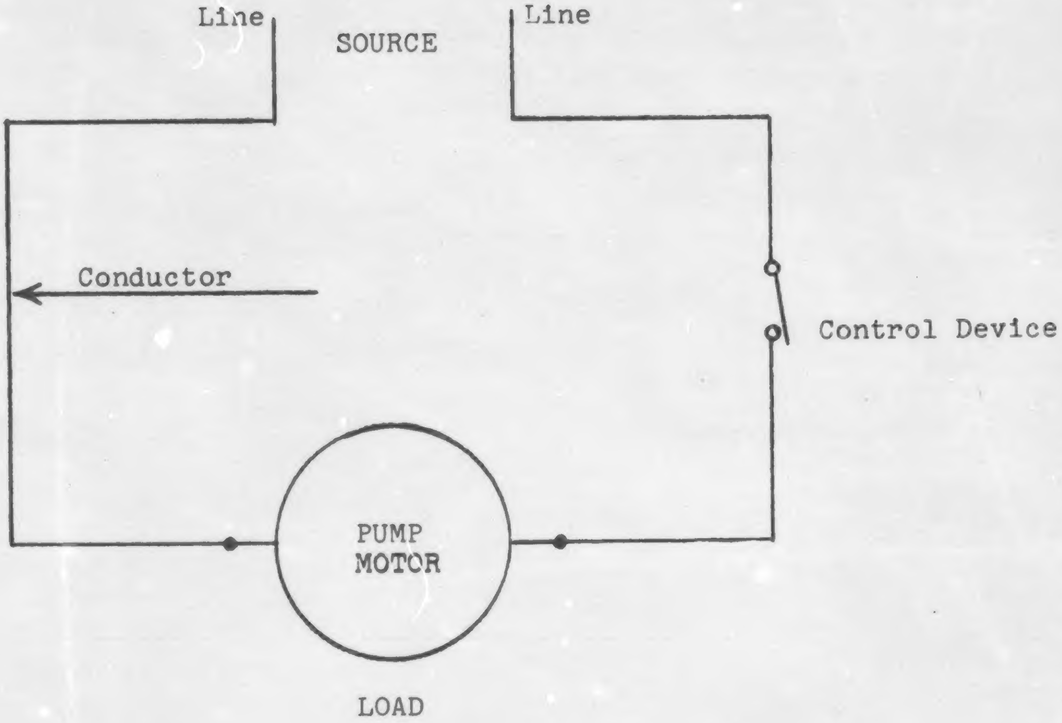
(NOTE: AWG stands for American Wire Gauge.)

Memory Aid For Ohm's Law



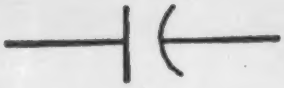
TM-1

BASIC CIRCUIT

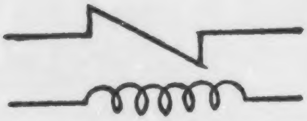


Symbols

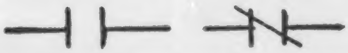
Capacitor



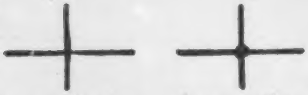
Coils



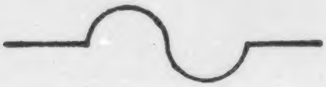
Contacts



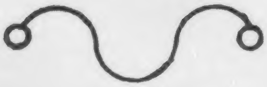
Conductors



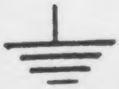
Fuse



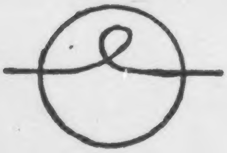
Fusible Link



Ground
Connection

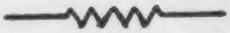


Light

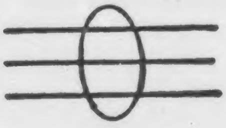


Symbols
(Continued)

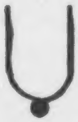
Resistor



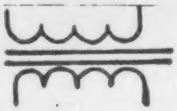
Multiple Conductor Cable



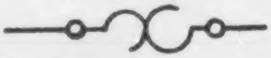
Thermocouple



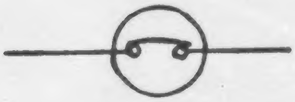
Transformer



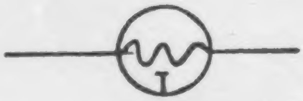
Thermal Overload



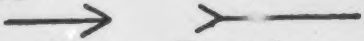
Bimetal Switch



Thermistor

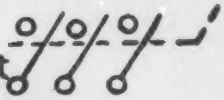


Connectors

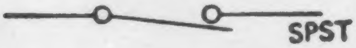


Male Female

Switch Disconnect

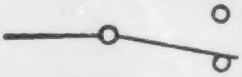


Single Pole Single Throw



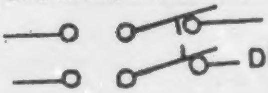
SPST

Single Pole Double throw



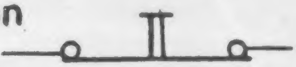
SPDT

Double Pole Double Throw



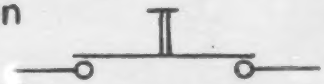
DPDT

Push Button



(Normally Closed)

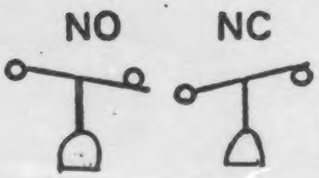
Push Button



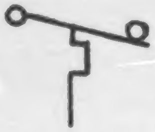
(Normally Open)

Symbols
(Continued)

Pressure

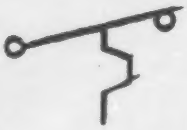


Temperature

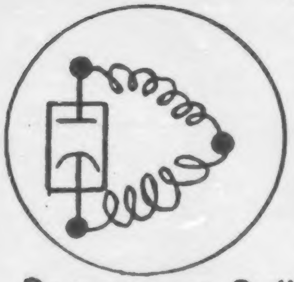


Close on Rise

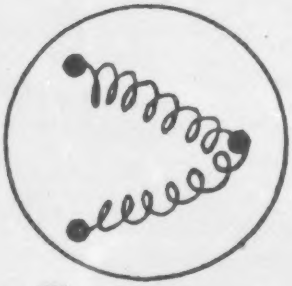
Temperature



Open on Rise

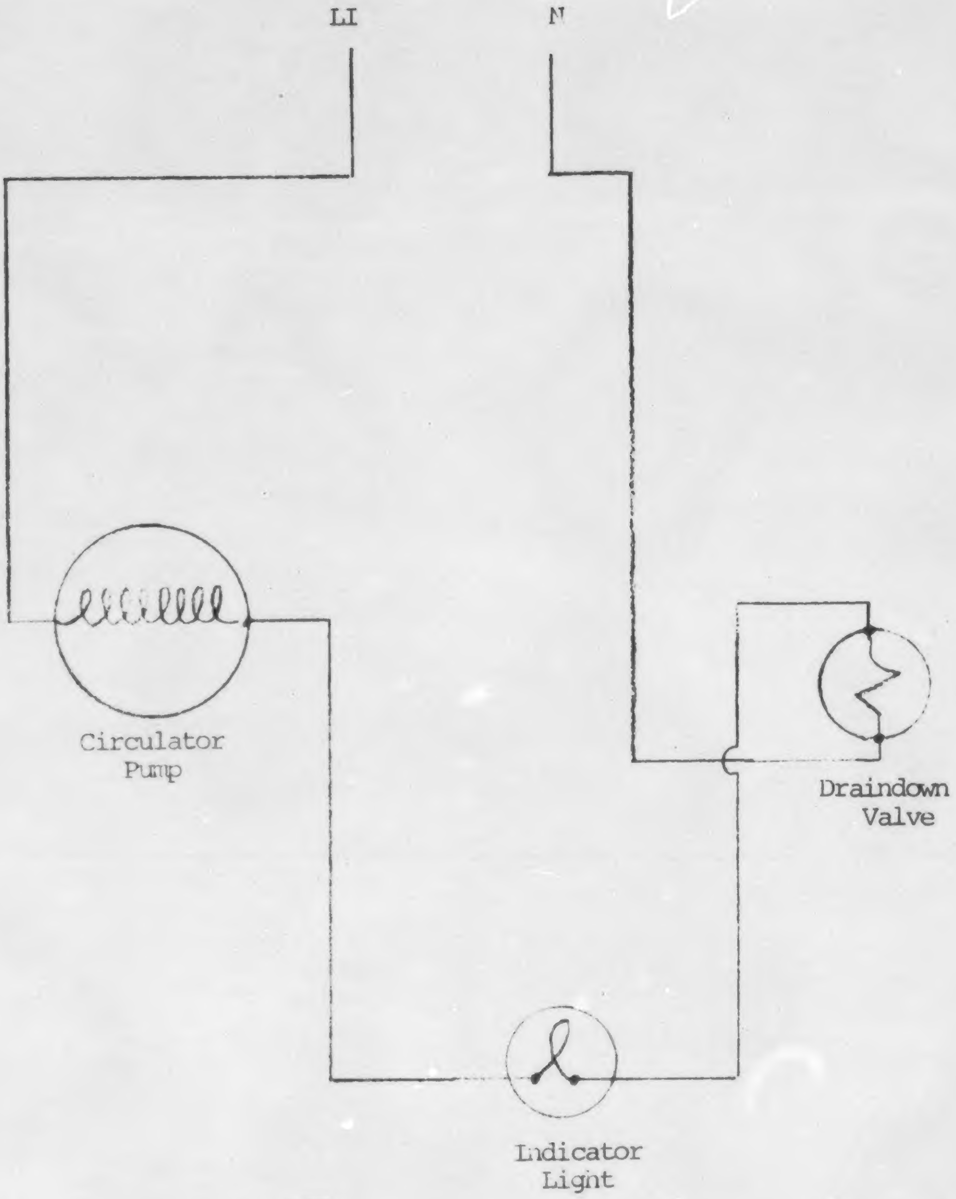


Permanent Split
Capacitor Motor

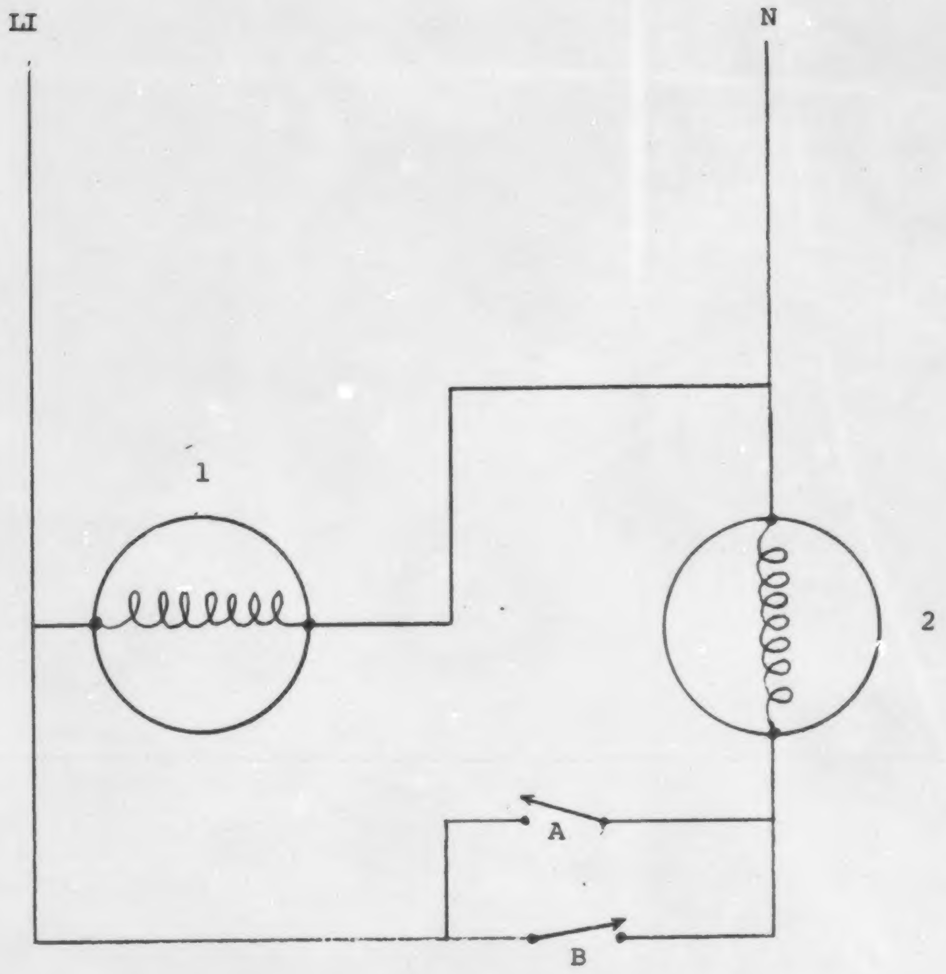


Single-Phase
Motor

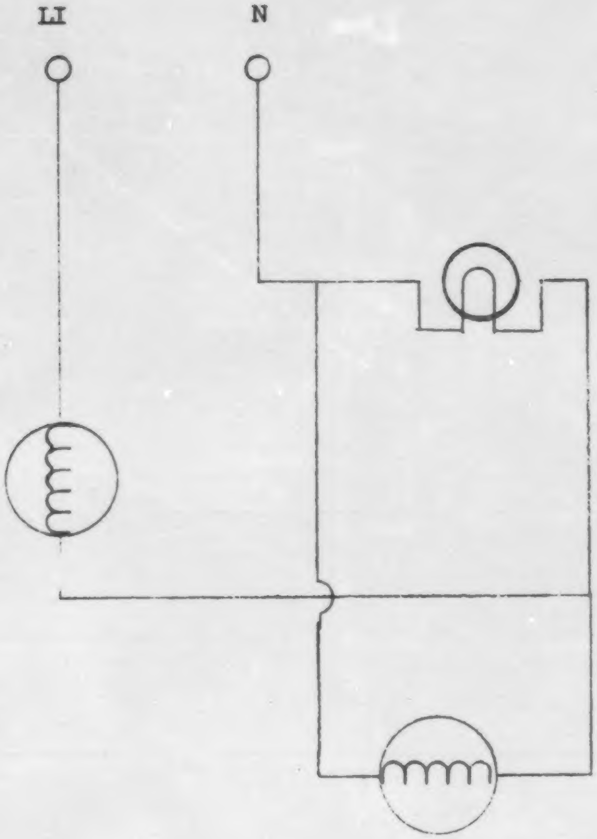
SERIES CIRCUIT

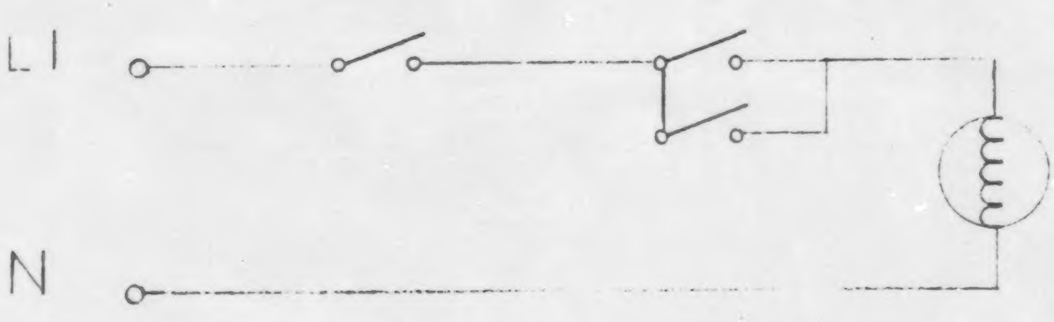


PARALLEL CIRCUITS



SERIES-PARALLEL CIRCUITS



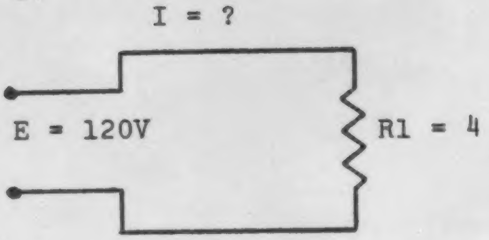


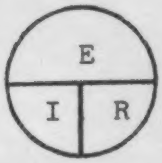
FUNDAMENTALS OF ELECTRICITY
UNIT I

ASSIGNMENT SHEET No. 1--USING OHMS LAW

Instructions: Use Ohms Law to solve the following:

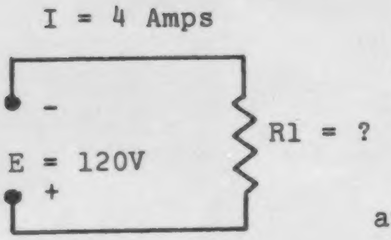
1.

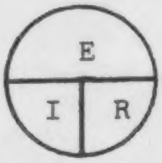




answer_______________

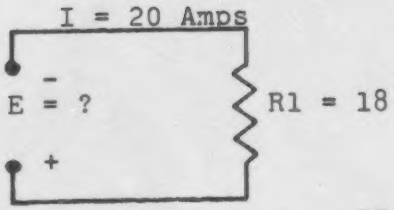
2.

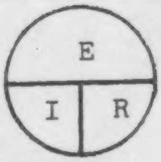




answer_______________

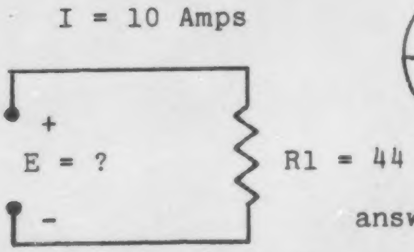
3.

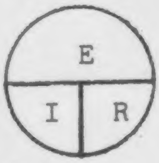




answer_______________

4.





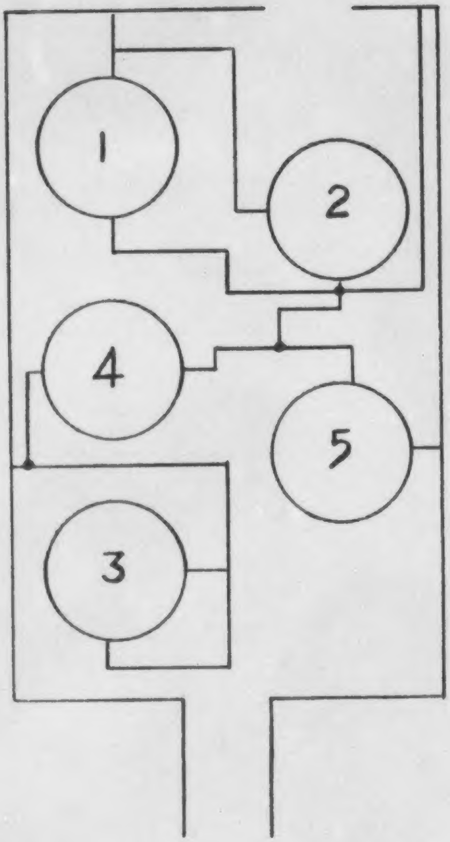
answer_______________

FUNDAMENTALS OF ELECTRICITY
UNIT I

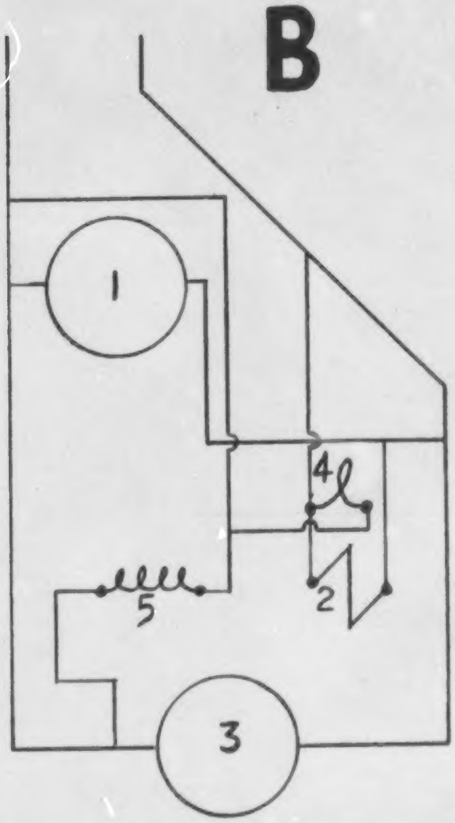
ASSIGNMENT SHEET NO. 2--SELECTION OF PARALLEL LOADS

Directions: Select the loads in the following circuits which are wired parallel to the voltage source, and which are not in series with another load. Place the appropriate load designating numbers in the space provided for each circuit at the bottom of the page.

A



B



A. ________ ________ ________ ________ ________

B. ________ ________ ________ ________ ________

FUNDAMENTALS OF ELECTRICITY
UNIT I

ANSWERS TO ASSIGNMENT SHEETS

Assignment sheet #1

1. 30 amps
2. 30 ohms
3. 360 volts
4. 440 volts

Assignment Sheet #2

a. 1 2 4

b. 3 1 4

FUNDAMENTALS OF ELECTRICITY
UNIT I

JOB SHEET NO. 1--SOLDER ELECTRICAL WIRE SPLICE

I. Tools and materials

- A. Soldering gun
- B. Diagonal cutters
- C. Long nose pliers
- D. Wire strippers
- E. Safety glasses
- F. Rosin core solder
- G. Two 6-inch pieces stranded copper wire #16 AWG
- H. Wire terminal--1/4" female spade type

II. Procedure

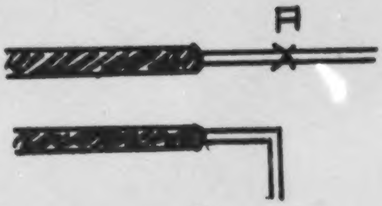
- A. Put on safety glasses
- B. Strip one inch of insulation from the end of each wire

JOB SHEET #1

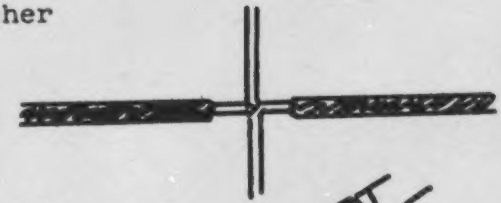
C. Twist the wire until it forms a solid wire (Figure 1)

STRAIGHT SPLICE

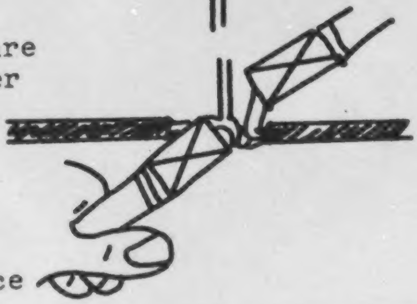
1) Bend 90° angles in both conductors at point A



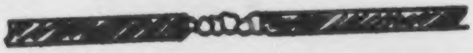
2) Hook conductors together



3) Hold one conductor secure while wrapping the other



4) Finished straight splice



D. Clean tip of soldering gun

E. Place the splice on the work bench

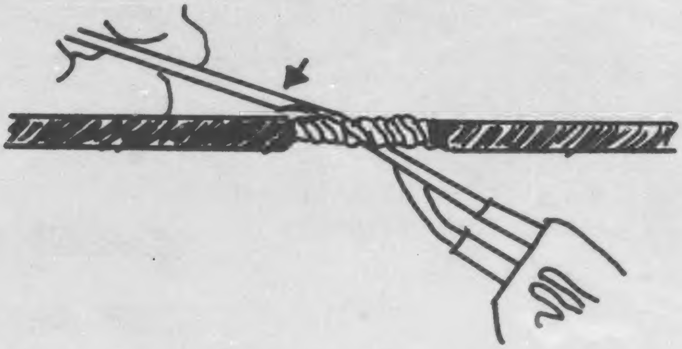
(NOTE: The splice should not touch the bench.)

F. Heat soldering gun tip

G. Apply a small amount of solder to the tip

H. Hold the soldering gun on the splice

I. Apply solder to the splice (Figure 2)



J. Remove the solder when the splice fills

K. Strip other end of wire one-half inch from end

L. Heat bare wire with soldering gun

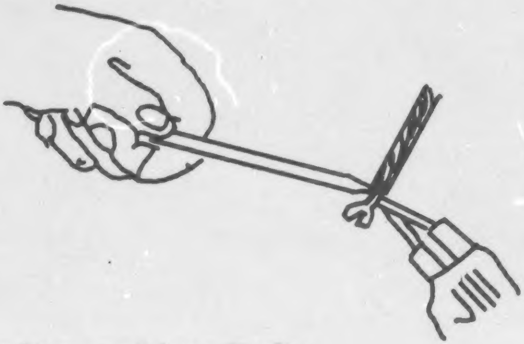
M. Apply solder until it fills all strands

(NOTE: This process of applying a coating of solder is referred to as tinning.)

N. Crimp a wire terminal onto the tinned portion of wire

O. Heat the terminal with the soldering gun (Figure 3)

P. Apply solder



Q. Remove gun after solder flows

R. Have the instructor inspect

S. Clean up and put away tools

S-39-B

FUNDAMENTALS OF ELECTRICITY
UNIT I

NAME________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Conductor which has a resistance valve in between a good conductor and an insulator

_____b. Material with an extremely high resistance to current flow

_____c. Negatively charged particles

_____d. One complete reversal of an alternating current from positive to negative and back to the starting point in one second

_____e. Unit of power measurement

_____f. Voltage induced in a conductor which is moving through a magnetic field in opposition to the source voltage

_____g. Electrical circuit containing semiconductors

_____h. Potential difference which causes current to flow

_____i. Property in an electrical circuit which opposes any change in the existing current

_____j. Flow of electrons through a conductor measured in amperes

_____k. Any material with the ability to permit passage of electrical current

_____m. Factor in an electrical circuit that allows for the storage of electrical charges and opposes any change in existing voltage

1. Resistance
2. Electrons
3. Impedance
4. Semiconductor
5. Watt
6. Solid state
7. Hertz (cycle)
8. Insulator
9. Counter EMF
10. Inductance
11. Voltage (EMF)
12. Capacitance
13. Conductor

15. Current
16. Parallel circuit
17. Series circuit
18. Series-parallel circuit
19. Branch
20. Low line voltage
21. Load

_____n. Opposition to current flow measured in ohms

_____o. Total opposition in an electrical circuit to the flow of alternating current

_____p. That portion of a total circuit which is independent of other portions with each receiving full supply voltage

_____q. Current has only one path it can take

_____r. Power consuming device

_____s. Electrical circuit consisting of both series and parallel circuits

_____t. Decrease in voltage available to a power consuming device

_____u. Current has more than one path it can take

2. Distinguish between direct and alternating current by placing "AC" in front of the items that refer to alternating current and "DC" in front of the items that refer to direct current.

_____a. Flows in one direction then reverses and flows in the opposite direction

_____b. Dry cell battery

_____c. Supplied by an alternating current generator (alternator)

_____d. Flows in one direction only

3. List six materials which are good conductors of electricity.

a.

b.

c.

d.

e.

f.

4. List five materials which are good insulators of electricity.

   a.

   b.

   c.

   d.

   e.

5. List the equation symbols and equations for Ohm's Law.

   a. Equation symbols

      1)

      2)

      3)

   b. Equations

      1)

      2)

      3)

6. List four common conversions of wattage.

   a.

   b.

   c.

   d.

7. List the four basic parts of a complete electrical circuit.

   a.

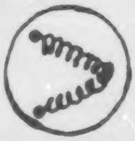
   b.

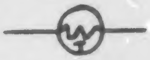
   c.

   d.

8. Match terms to the correct basic electrical symbols.

_____a. Single pole single throw (SPST)
_____b. Ground connection
_____c. Capacitor
_____d. Push button (normally open)
_____e. Switches disconnect
_____f. Permanent split capacitor motor
_____g. Light
_____h. Contacts
_____i. Coil
_____j. Bimetal switch
_____k. Temperature switch
_____l. Double pole double throw (DPDT)
_____m. Push button (normally closed)
_____n. Thermal overload
_____o. Fusible link
_____p. Resistor or resistance heater
_____q. Single-phase motor
_____r. Single pole double throw (SPDT)
_____s. Thermocouple
_____t. Thermistor
_____u. Connectors
_____v. Pressure switches
_____w. Transformer
_____x. Multiple conductor cable
_____y. Conductors
_____z. Fuse

1.


2.


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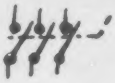

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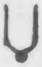

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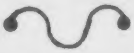

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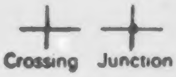

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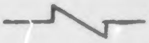

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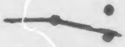

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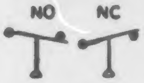

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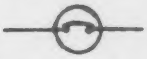

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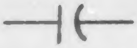

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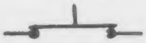

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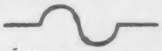

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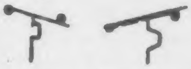

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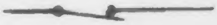

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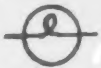

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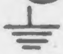

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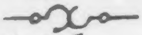

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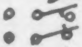

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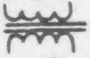

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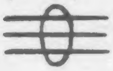

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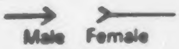

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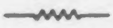
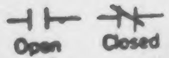
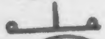
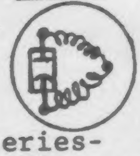
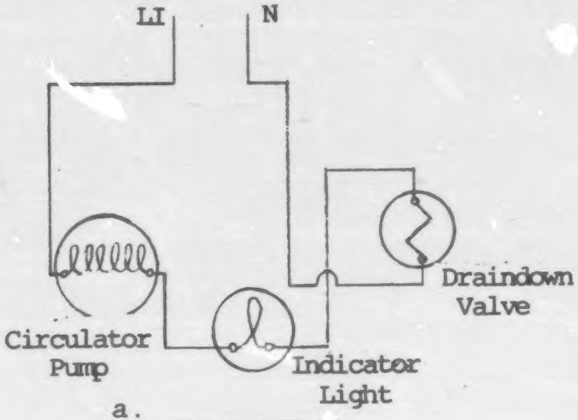


24. 

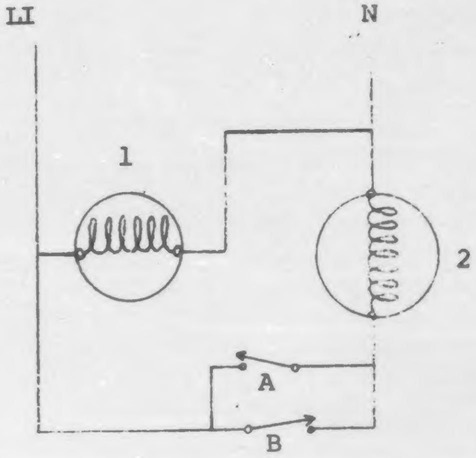
25. 

26. 

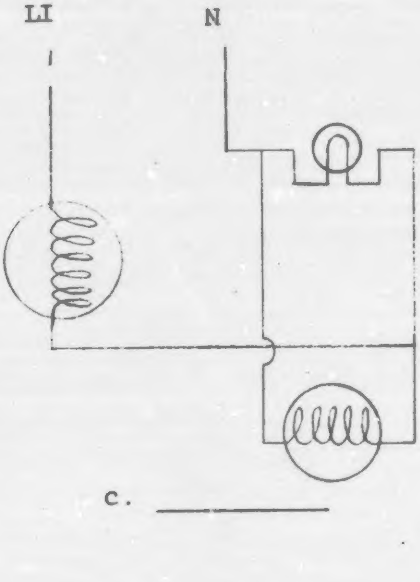
9. Distinguish between a series, parallel and series-parallel circuit by placing an "s" under the picture of a series circuit, a "p" under the picture of a parallel circuit, and an "s-p" under the picture of a series-parallel circuit.



a. ______________



b. ______________



c. ______________

10. State four rules for series circuits.

    a.

    b.

    c.

    d.

11. State three rules for a parallel circuit.

    a.

    b.

    c.

12. Match the amperage loads on the right to the correct wire sizes.

Wire Size	Amperage loads
_____a. 8	1. 40
_____b. 14	2. 15
_____c. 6	3. 70
_____d. 4	4. 55
_____e. 12	5. 30
_____f. 10	6. 20

13. Demonstrate the ability to:

    a. Use Ohm's Law.

    b. Select the parallel loads.

    c. Solder electrical wire.

    (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

FUNDAMENTALS OF ELECTRICITY
UNIT I

ANSWERS TO TEST

1. a. 4
   b. 8
   c. 2
   d. 7
   e. 5
   f. 9
   g. 6
   h. 11
   i. 10
   j. 15
   k. 13
   m. 12
   n. 1
   o. 3
   p. 19
   q. 17
   r. 21
   s. 18
   t. 20
   u. 16

2. a. AC
   b. DC
   c. AC
   d. DC

3. Any six of the following:
   a. Silver
   b. Copper
   c. Gold
   d. Aluminum
   e. Tungsten
   f. Zinc
   g. Brass
   h. Platinum
   i. Iron
   j. Nickel
   k. Tin
   l. Steel
   m. Lead
   n. Mercury
   o. Nichrome
   p. Air
   q. Water

4. Any five of the following:
   a. Glass
   b. Rubber
   c. Plastic
   d. Wood
   e. Ceramic
   f. Mica

5. a. Equation symbols
    1) E= Potential measured in volts
    2) I= Current flow measured in amperes
    3) R= Resistance measured in ohms
   b. Equations
    1) $E = I \times R$
    2) $I = E/R$
    3) $R = E/I$
6. a. 1,000 watts = 1 kilowatt (kw)
   b. 1,000,000 watts = 1 megawatt
   c. 746 watts = 1 horsepower (hp)
   d. 1 watt-hour = 3.413 b.t.u.'s
7. a. Power source
   b. Connecting wiring
   c. Load
   d. Control device
8. a. 15
   b. 17
   c. 11
   d. 12
   e. 3
   f. 26
   g. 16
   h. 24
   i. 7
   j. 10
   k. 14
   l. 19
   m. 25
   n. 18
   o. 5
   p. 23
   q. 1
   r. 8
   s. 4
   t. 2
   u. 22
   v. 9
   w. 20
   x. 21
   y. 6
   z. 13
9. a. s
   b. p
   c. s-p
10. a. The current is the same throughout the circuit.
    b. The sum of the voltage drops around a series circuit will equal the supply voltage.

c. The largest voltage drop occurs in the component with the highest resistance.

d. The sum of the resistances of the components equals the total resistance.

11. a. Total current equals the sum of the current in all branches.

    b. Voltage is the same across all branches.

    c. Total resistance is always less than the smallest branch resistance.

12. a. 1

    b. 2

    c. 4

    d. 3

    e. 6

    f. 5

13. Performance skills evaluated to the satisfaction of the instructor.

ELECTRIC POWER
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms and distinguish between single-phase and three-phase current characteristics. The student should also be able to list three ways of providing ground protection and read an electric watt-hour meter. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with electric power to the correct definitions.
2. Distinguish between single-phase and three-phase current characteristics.
3. List three methods of grounding an electrical circuit.
4. List three effects of low line voltage.
5. List four steps in power distribution.
6. Demonstrate the ability to read an electric watt-hour meter.

ELECTRIC POWER
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and assignment sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information and assignment sheets.

  F. Invite a power company representative to talk to the class.

  G. Reemphasize electrical safety rules

  H. Give test.

II. Student;

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete assignment sheet.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Power Distribution

    2. TM 2--Grounding

  D. Assignment Sheet #1--Read An Electric Watt-Hour Meter

E. Answers to assignment sheet

F. Test

G. Answers to test

II. Reference--Woodroof, William Walton. Servicing Comfort Cooling Systems. Columbus, Ohio: NHAW Home Study Institute, 1974.

ELECTRIC POWER
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. Single-phase--Alternating current circuit with only two current carrying conductors

B. Three-phase--Alternating current circuit with three current carrying conductors

C. "Hot" conductor--Current carrying conductor in a circuit; should be any color other than white, green, or natural grey

D. Grounded conductor--System or circuit conductor which is intentionally grounded, colored green or bare wire

E. Neutral--Term used to designate a conductor connected to the center tap of the transformer

(NOTE: The neutral conductor is a current carrying conductor and should not be confused with the equipment ground, even though they will terminate at the same block.)

F. Step-up transformer--Transformer which increases the secondary voltage

G. Step-down transformer--Transformer which decreases the secondary voltage

H. Electric watt-hour meter--Meter consisting of four clock-type dials which indicates the number of kilowatt hours used in a given amount of time transformer

I. Primary voltage--Voltage supplied to the input or primary winding of a transformer

J. Leg--Term used to designate one conductor of a power supply

K. Secondary voltage--Output voltage, or the voltage that is supplied from the secondary side of the transformer

L. Equipment ground--Conductor connected to equipment case and to an intentional ground, colored green or bare wire

II. Single-phase and three-phase current characteristics

A. Single-phase

1. Two current carrying conductors
2. Generally used for residences and small commercial applications
3. Several voltages from 12 volt to 240 volt
4. Can be taken from a three-phase supply
5. Motors frequently require starting components

B. Three-phase

1. Generally commercial and industrial installations
2. Various combinations of voltages
3. Fewer service problems on motors
4. Can be used to supply single-phase power
5. Needs no motor starting capacitors
6. Voltage balance is important

III. Methods of grounding an electrical circuit (Transparency 2)

A. Cold water pipes

(NOTE: Be sure that the water pipe does not connect onto a plastic water line.)

B. Metal stake

C. Metal case of main distribution panel

IV. Effects of low line voltage on motors

1. Reduces starting torque
2. Reduces running efficiency
3. Increases temperature rise

V. Power distribution (Transparency 1)

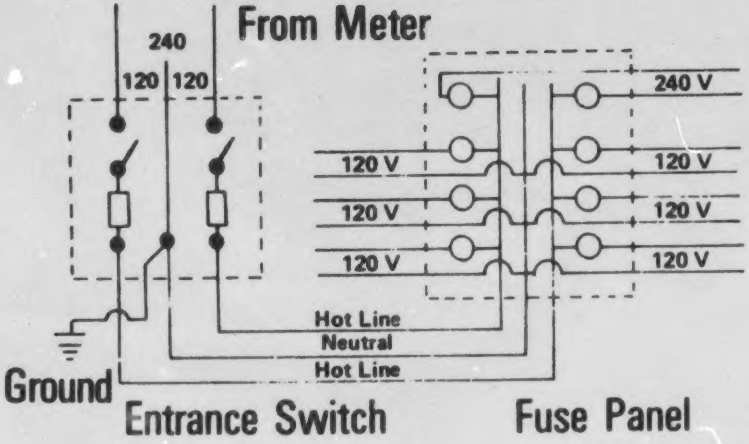
  A. Step-down transformers on power pole

  B. Service to individual home or small business

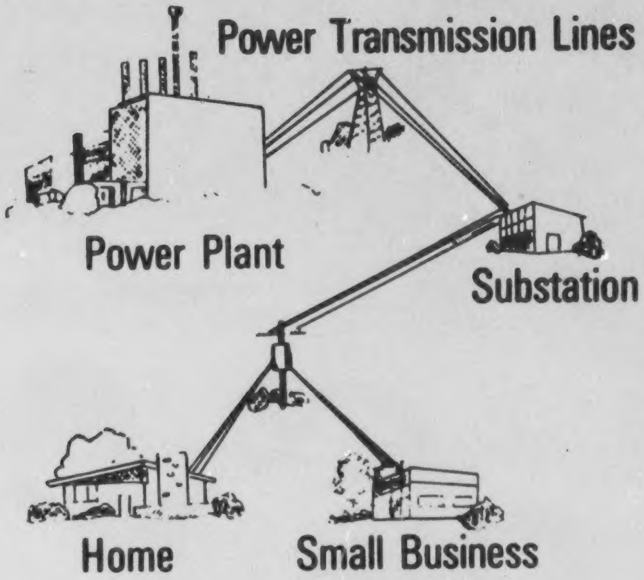
  C. Circuit box

  D. Individual circuits

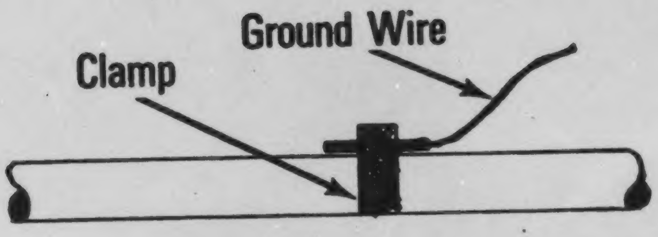
Power Distribution



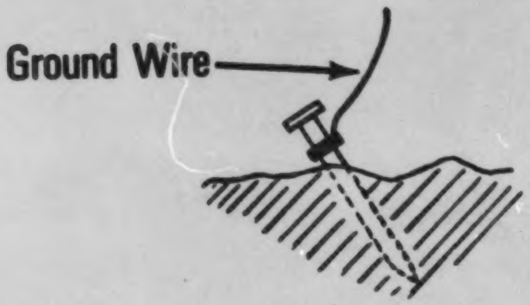
Power Distribution In A Home Or Small Business
Single-Phase



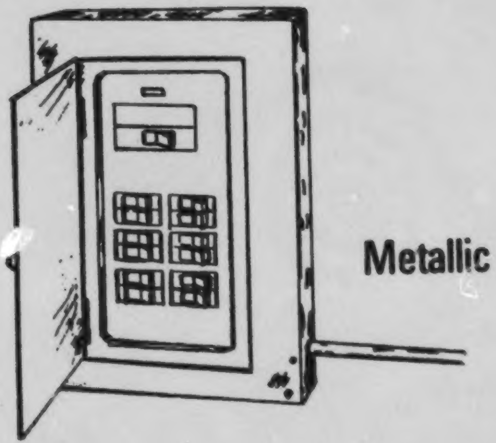
Grounding



Cold Water Pipe



Grounding Rod



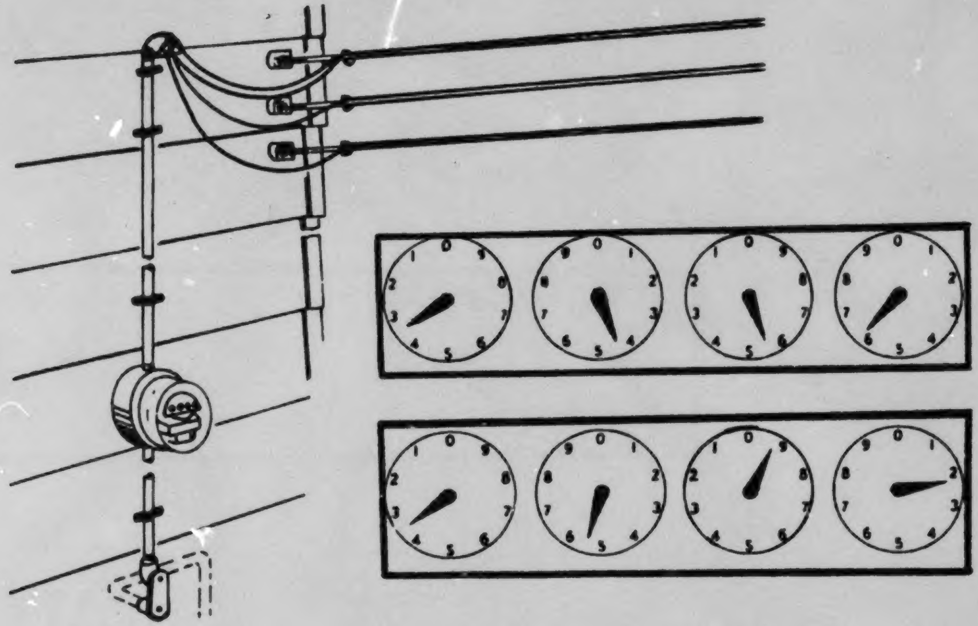
Metallic Conduit

ELECTRIC POWER
UNIT II

ASSIGNMENT SHEET #1--READ AN ELECTRIC WATT-HOUR METER

The electric meter on the house indicates how much current has been consumed in a given amount of time. This is determined by reading a series of dials.

EXAMPLE:



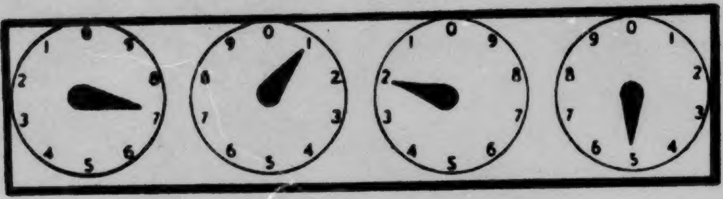
The power company's "Watt-meter" has four dials. Each dial has a hand. Note that two dials read clockwise and two read counter-clockwise.

Write down the number that the hand has just passed on each of the dials in the top row. Suppose the reading on dials is 3456 (KWH) Kilowatt hours as shown above. Let's assume the above figures represent the reading at beginning of the month. Suppose at the end of the month the readings appear as on dials in lower row. Reading as before, we obtain 3592 (KWH) Kilowatt hours. The difference is as follows:

S-62-B

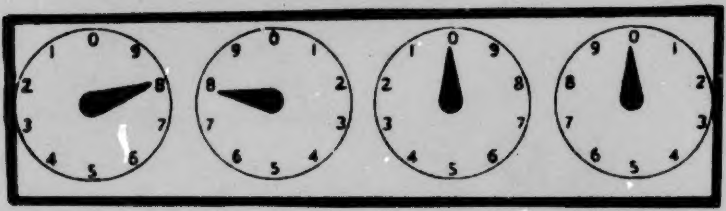
This month's reading	3592
Last month's reading	3456
Kilowatt hours used in month	136

1. Read the following dials:



ans. ______________________

2. Read the following dials:



ans. ______________________

3. How many kilowatt hours were consumed between problems one and two?

ans. ______________________

ELECTRIC POWER
UNIT II

ANSWERS TO ASSIGNMENT SHEET

1. 7125

2. 8800

3. 1675

S-65-B

ELECTRIC POWER
UNIT II

NAME____________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Output voltage, or the voltage that is supplied from the secondary side of the transformer

_____b. Term used to designate a conductor connected to the center tap of the transformer

_____c. Current carrying conductor in a circuit; should be any color other than white, green, or natural grey

_____d. Alternating current circuit with three current carrying conductors

_____e. System or circuit conductor which is intentionally grounded, colored green or bare wire

_____f. Term used to designate one conductor of a power supply

_____g. Meter consisting of four clock-type dials which indicates the number of kilowatt hours used in a given amount of time

_____h. Voltage supplied to the input or primary winding of a transformer

_____i. Alternating current circuit with only two current carrying conductors

_____j. Transformer which decreases the secondary voltage

_____k. Transformer which increases the secondary voltage

1. Electric watt-hour meter
2. Step-down transformer
3. Neutral
4. Three-phase
5. Step-up transformer
6. Primary voltage
7. Grounded conductor
8. Single-phase
9. "Hot" conductor
10. Secondary voltage
11. Leg

2. Distinguish between single-phase and three-phase currents by placing an "S" in front of the single-phase characteristics and a "T" in front of the three-phase characteristics.

_____a. Two current carrying conductors

_____b. Fewer service problems on motors

_____c. Can be taken from a three-phase supply

_____d. Generally used for residences and small commercial applications

_____e. Generally commercial and industrial installations

_____f. Several voltages from 12 volt to 240 volt

_____g. Needs no motor starting capacitors

_____h. Motors frequently require starting components

_____i. Voltage balance is important

_____j. Can be used to supply single-phase power

3. List three methods of grounding an electrical circuit.

a.

b.

c.

4. List three effects of low line voltage on motors.

a.

b.

c.

5. List four steps in power distribution.

a.

b.

c.

d.

6. Demonstrate the ability to read an electric watt-hour meter.

   (NOTE: If this activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

ELECTRIC POWER
UNIT II

ANSWERS TO TEST

1. a. 10
   b. 3
   c. 9
   d. 4
   e. 7
   f. 11
   g. 1
   h. 6
   i. 8
   j. 2
   k. 5

2. a. S
   b. T
   c. S
   d. S
   e. T
   f. S
   g. T
   h. S
   i. T
   j. T

3. a. Cold water pipes
   b. Metal stake
   c. Metal case of main distribution panel

4. Effects
   a. Reduces starting torque
   b. Reduces running efficiency
   c. Increases temperature rise

5. a. Step-down transformers on power pole
   b. Service to individual home or small business
   c. Circuit box
   d. Individual circuits

6. Evaluated to the satisfaction of the instructor.

ELECTRICAL TEST INSTRUMENTS
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with electrical test instruments to the correct definitions, and list safety rules pertaining to electrical test instruments. The student should be able to read and use a voltmeter, ammeter, ohmmeter, wattmeter, and capacitor analyzer. The student should also be able to test a capacitor with an ohmmeter. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with electrical test instruments to the correct definitions.
2. List six safety rules pertaining to electrical test instruments.
3. List five general rules for the protection of electrical test instruments.
4. Identify electrical test instruments.
5. Match the meter to its application.
6. List two steps for reading a meter scale.
7. Match statements to circuit conditions
8. Describe the procedure for zeroing the ohmmeter.
9. Demonstrate the ability to:
    a. Read a voltmeter scale.
    b. Read an ammeter scale.
    c. Read an ohmmeter scale.
    d. Use a voltmeter.
    e. Use an ohmmeter.

f. Use a wattmeter.

g. Use an ammeter.

h. Use a capacitor analyzer.

i. Test a capacitor with an ohmmeter.

ELECTRICAL TEST INSTRUMENTS
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

A. Provide student with objective sheet.

B. Provide student with information, assignment, and job sheets.

C. Make transparencies.

D. Discuss unit and specific objectives.

E. Discuss information and assignment sheets.

F. Demonstrate and discuss the procedures outlined in the job sheets.

G. Demonstrate the use and care of electrical test instruments.

H. Obtain films from meter manufacturers.

I. Construct test boards.

J. Give each student a copy of the manufacturer's instructions for each electrical test instrument in the shop.

K. Give test.

II. Student:

A. Read objective sheet.

B. Study information sheet.

C. Complete assignment and job sheets.

D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

A. Objective sheet

B. Information sheet

C. Transparency masters
   1. TM 1--Electrical Test Instruments
   2. TM 2--Electrical Test Instruments(Continued)

D. Assignment sheets
   1. Assignment Sheet #1--Read a Voltmeter Scale
   2. Assignment Sheet #2--Read an Ammeter Scale
   3. Assignment Sheet #3--Read an Ohmmeter Scale

E. Answers to assignment sheets

F. Job sheets
   1. Job Sheet #1--Use a Voltmeter
   2. Job Sheet #2--Use an Ohmmeter
   3. Job Sheet #3--Use a Wattmeter
   4. Job Sheet #4--Use an Ammeter
   5. Job Sheet #5--Use a Capacitor Analyzer
   6. Job Sheet #6--Test a Capacitor With an Ohmmeter

G. Test

H. Answers to test

II. References:

A. Woodroof, William Walton. Servicing Comfort Cooling Systems. NHAW Home Study Institute, Columbus, Ohio, 1974.

B. Basic Electricity for Appliances. Indianapolis, Indiana: Howard W. Sams and Co., 1975.

ELECTRICAL TEST INSTRUMENTS
UNIT III

INFORMATION SHEET

I. Terms and definitions

A. Zero--To align meter needle over zero on the ohm scale.

B. Range--Limits of a particular portion of a meter

Example: 250 VAC (volts alternating current)--This range would be all right to use for any AC voltage 1 VAC to 250 VAC; anything over that would damage the meter.

C. Calibrate--To adjust a meter so that the needle is properly aligned to the proper set point on the scale.

D. Continuity--Complete circuit in which current can flow

E. Line voltage--Main power supply

F. Probes--Insulated ends on a test instrument's leads that are held while checking a circuit

G. Locked rotor amperage (L.R.A.)--Amperage a motor would draw when the rotor is not turning with power applied

H. Full load amperage (F.L.A.)--Total current a device draws when it is running fully loaded

I. Infinity (infinite resistance)--Extreme end of the ohm scale; designated by ∞

II. Safety rules pertaining to electrical test instruments

A. Stand on dry, nonconductive surfaces when testing live circuits

B. Be sure the power is off when checking a circuit with an ohmmeter

(NOTE: An ohmmeter could explode if it came into contact with line voltage.)

C. Do not use meter leads with defective probes

D. Do not have both hands in a high voltage cabinet

(NOTE: Clip one voltmeter lead on and then take the other lead and check

E. Do not touch metal cabinet or other grounded material

F. Wear eye protection

G. Use fuse pullers

H. Do not assume that the power is off

I. Discharge capacitors with a bleed resistor before removing or testing

III. General rules for the protection of electrical test instruments

A. Keep stored in proper cases

B. Avoid bumping or jolting

C. Use only for intended purpose

D. Use within meter range limits

E. Avoid exposure to extreme temperatures

F. Keep clean

G. Keep dry

H. Set meter in highest range prior to taking reading

IV. Electrical test instruments (Transparencies 1 and 2)

A. Voltmeter

B. Ohmmeter

C. Multimeter

D. Wattmeter

E. Ammeter

F. Capacitor analyzer

V. Meter application

A. Voltmeter

1. Measures line voltage

2. Measures voltage drop at the load
3. Measures low voltage
4. Indicates open components

   (NOTE: A switch or other nonload circuit component will give a voltage reading across it if it is open.)

B. Ohmmeter

(CAUTION: Be sure all power is off before checking an electrical circuit with an ohmmeter.)

1. Checks for a path for current flow (continuity)
2. Checks for resistance to current flow
3. Determines motor windings
4. Checks for shorts and grounds
5. Checks capacitors

   (CAUTION: Be sure that the charge is bled off of a capacitor with a bleed resistor before checking it with an ohmmeter.)

C. Multimeter

1. AC voltmeter
2. DC voltmeter
3. Ohmmeter
4. Milliammeter

D. Wattmeter

1. Indicates line voltage
2. Indicates starting watts
3. Indicates running watts

E. Ammeter

1. Checks starting amperage
2. Checks running amperage

        3. Checks locked rotor amperage

    F. Capacitor analyzer

        1. Measures capacitance value
        2. Measures power factor
        3. Indicates open capacitors
        4. Indicates shorted capacitors
        5. Indicates leaky capacitors

VI. Steps for reading a meter scale

    A. Read meter in the center two-thirds of the scale for greater accuracy

    B. Count the number of graduations between the major divisions

VII. Circuit conditions

    A. Open circuit

        1. Most frequent circuit problem
        2. No path for current flow
        3. Caused by
            a. Pitted contacts
            b. Defective relay coil
            c. Broken wire
            d. Blown fuse
            e. Tripped circuit breaker
            f. Open switch
        4. Voltmeter will indicate voltage across an open

    B. Short circuit

        1. Second most frequent circuit problem
        2. Electrical circuit that has a lower resistance than intended

3. Indications
    a. Blown fuses
    b. Tripped circuit breakers
    c. Melted wires
    d. Swollen run capacitor cans
    e. Blackened terminals
    f. Burnt case

Example: Touching a screwdriver to a current carrying conductor and at the same time against the side of the appliance cabinet would result in a blown fuse, a badly burnt screwdriver, a burnt spot on the cabinet, and possible personal injury

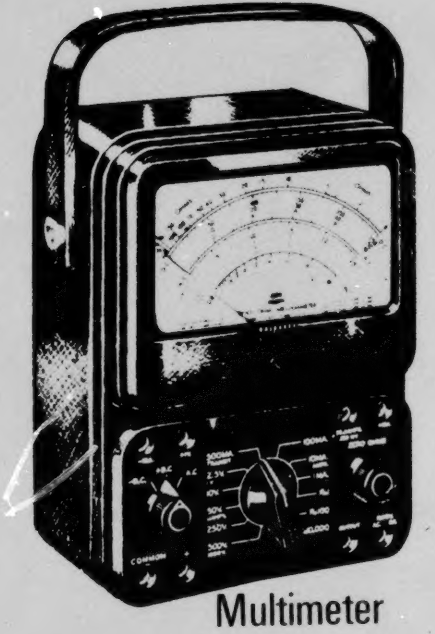
C. Grounded circuit
  1. A high resistance path that current may take to a common ground
  2. May not cause a blown fuse or tripped circuit breaker

VIII. Zeroing the ohmmeter
  A. Select range
  B. Hold leads together
  C. Check to see that the needle moves to the extreme right
  D. Align the needle directly over "0" on the ohm scale

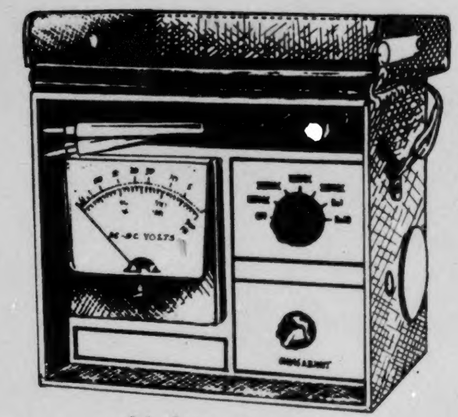
  (NOTE: If the meter cannot be zeroed the meter's batteries will have to be changed.)

  E. Zero ohmmeter each time before using or when changing ranges

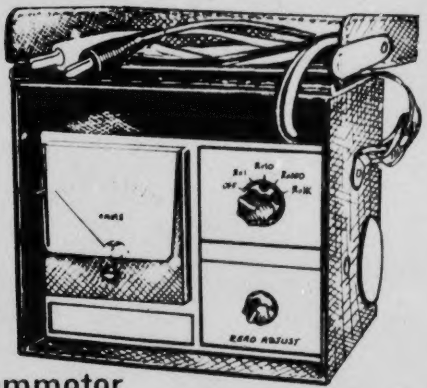
Electrical Test Instruments



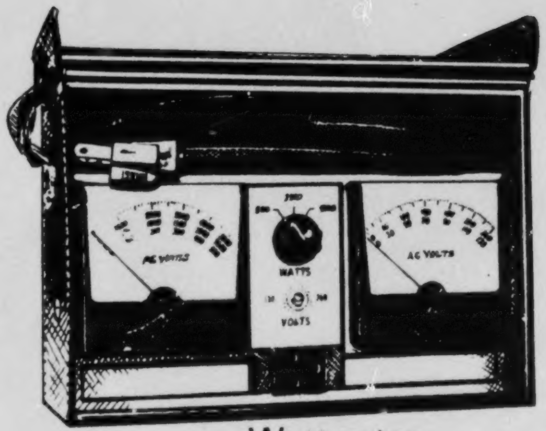
Multimeter



Voltmeter



Ohmmeter

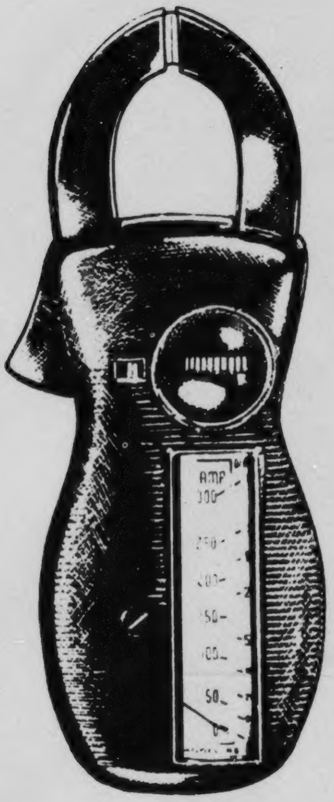


Wattmeter

Electrical Test Instruments

(Continued)

Capacitor Analyzer



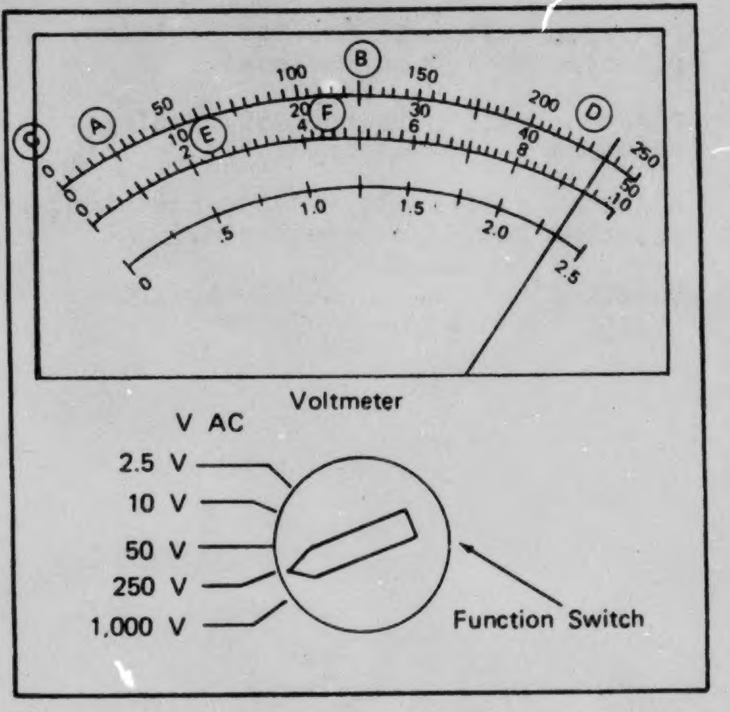
Ammeter

ELECTRICAL TEST INSTRUMENTS
UNIT III

ASSIGNMENT SHEET #1--READ A VOLTMETER SCALE

Read the voltages on the meter in Figure 1. This voltmeter will read from left to right on the scale. The scale to use is determined by the position of the function switch.

FIGURE 1



Example: With the function switch at 250v, the needle on the meter is indicating 235v

1. Function switch in the 250v position. Needle is pointing to "B" on the scale.

2. Function switch in the 50v position. Needle is pointing to "B" on the scale.

3. Function switch in the 1000v position.

   (NOTE: Use the 0-10 scale when in the 1000v position)

   Needle is pointing to "E" on the scale.

ASSIGNMENT SHEET #1

4. Function switch in the 250v position. Needle is pointing to "A" on the scale.

5. Function switch in the 250v position. Needle is pointing to "C" on the scale.

6. Function switch in the 1000v position. Needle is pointing to "F" on the scale.

7. Function switch in the 50v position. Needle is pointing to "F" on the scale.

8. Function switch in the 250v position. Needle is pointing to "D" on the scale.

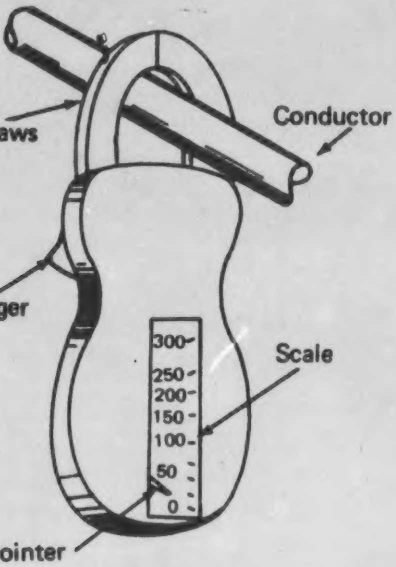
9. Function switch in the 250v position. Needle is pointing to "F" on the scale.

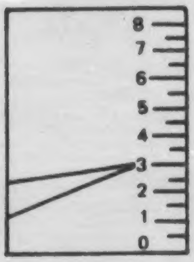
10. Function switch in the 50v position. Needle is pointing to "D" on the scale.

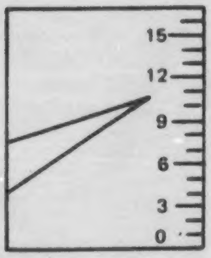
ELECTRICAL TEST INSTRUMENTS
UNIT III

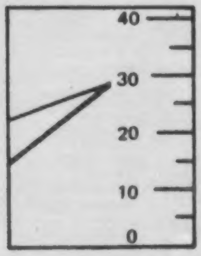
ASSIGNMENT SHEET #2--READ AN AMMETER SCALE

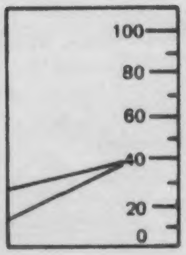
Read the amperages on the scales below. The ammeter shown has a rotary scale with five amperage scales on it.

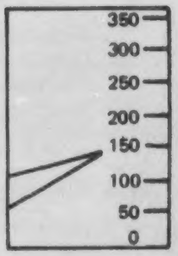












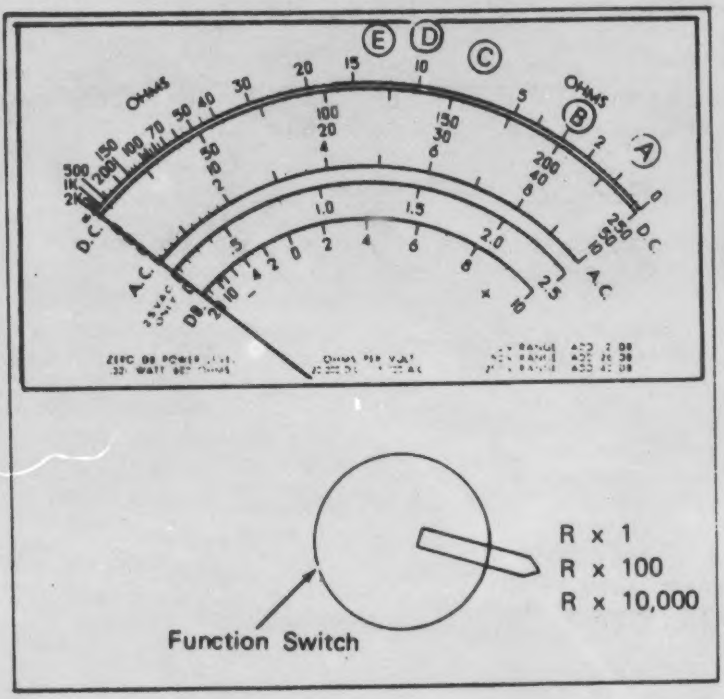
1. ________ 2. ________ 3. ________ 4. ________ 5. ________

(NOTE: Always set the ammeter on its highest scale and then come down to a lower scale for a more accurate reading.)

ELECTRICAL TEST INSTRUMENTS
UNIT III

ASSIGNMENT SHEET #3--READ AN OHMMETER SCALE

Read the resistances on the ohmmeter scale below. This ohmmeter scale reads from right to left.



(NOTE: The letters on the scale are there for the purpose of working this exercise and they do not appear on actual ohmmeters.)

Example: With the function switch at R x 10,000 and the needle pointing at 2 on the scale

$$\begin{array}{r} 10{,}000 \\ \times 2 \\ \hline 20{,}000 \end{array}$$

ans. 20,000 ohms

1. Function switch in the R x 1 position. Needle is pointing to "B" on the scale.

   ans. ________________

2. Function switch in the R x 10,000 position. Needle is pointing to "E" on the scale.

   ans. ________________

3. Function switch in the R x 100 position. Needle is pointing to "C" on the scale.

ans. ____________________

4. Function switch in the R x 10,000 position. Needle is pointing to "A" on the scale.

ans. ____________________

5. Function switch in the R x 1 position. Needle is pointing to "E" on the scale.

ans. ____________________

6. Function switch in the R x 100 position. Needle is pointing to "B" on the scale.

ans. ____________________

7. Function switch in the R x 1 position. Needle is pointing to "A" on the scale.

ans. ____________________

8. Function switch in the R x 1 position. Needle is pointing to "D" on the scale.

ans. ____________________

9. Function switch in the R x 100 position. Needle is pointing to "E" on the scale.

ans. ____________________

10. Function switch in the R x 10,000 position. Needle is pointing to "C" on the scale.

ans. ____________________

ELECTRICAL TEST INSTRUMENTS
UNIT III

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. 125 volts
2. 25 volts
3. 240 volts
4. 25 volts
5. 0 volts
6. 440 volts
7. 22 volts
8. 225 volts
9. 110 volts
10. 45 volts

Assignment Sheet #2

1. 3 amps
2. 11 amps
3. 30 amps
4. 40 amps
5. 150 amps

Assignment Sheet #3

1. 3 ohms
2. 130,000 ohms
3. 700 ohms
4. 10,000 ohms
5. 13 ohms

6. 300 ohms
7. 1 ohms
8. 10 ohms
9. 1,300 ohms
10. 70,000 ohms

ELECTRICAL TEST INSTRUMENTS
UNIT III

JOB SHEET #1--USE A VOLTMETER

I. Tools and materials

A. Voltmeter

B. Safety glasses

C. 120 VAC wall outlet

D. 240 VAC wall outlet

E. 240 VAC 1 phase disconnect

(NOTE: All of these materials should be connected to the proper voltage.)

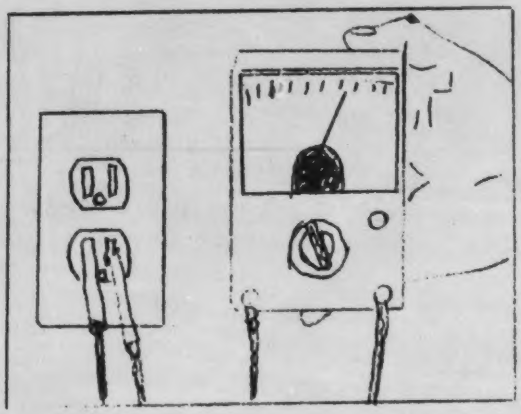
II. Procedure

A. Put on safety glasses

B. Select highest AC scale

C. Check across a 120 VAC wall outlet (Figure 1)

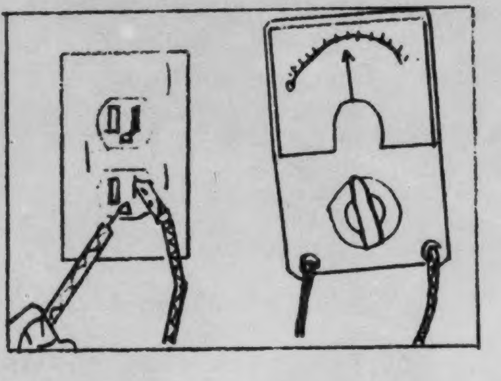
FIGURE 1



D. Select meter scale that will allow for the most accurate reading

E. Check from each side to ground (Figure 2)

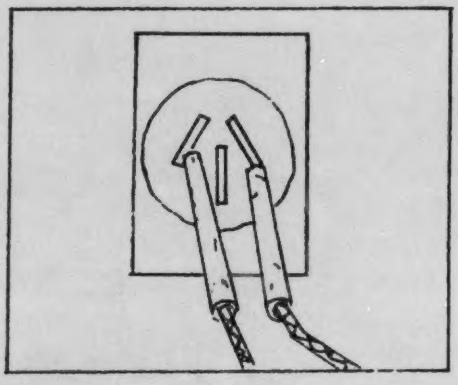
FIGURE 2



F. Switch to highest AC scale

G. Check across a 240 VAC wall outlet (Figure 3)

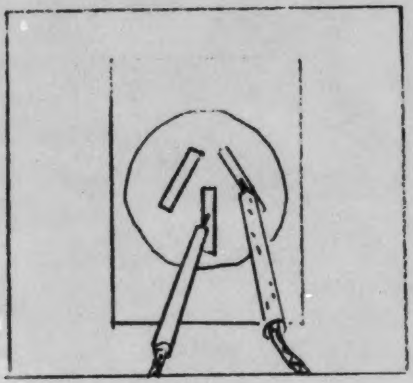
FIGURE 3



H. Select meter scale that will allow for the most accurate reading

I. Check from each side to ground (Figure 4)

FIGURE 4



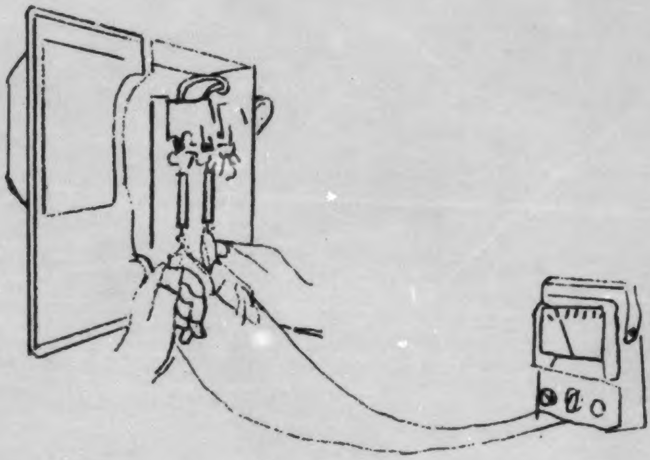
J. Switch to highest AC scale

K. Check line side of disconnect

L. Select meter scale that will allow for the most accurate reading

M. Check load side of disconnect (Figure 5)

FIGURE 5



N. Have instructor observe your work

O. Put away voltmeter

ELECTRICAL TEST INSTRUMENTS
UNIT III

JOB SHEET #2--USE AN OHMMETER

I. Tools and materials

   A. Ohmmeter

   B. Safety glasses

   C. Bleed resistor--2 watt 20K ohm

   D. Pump motor, single-phase

   E. Plug type fuse

   F. Cartridge type fuse

II. Procedure

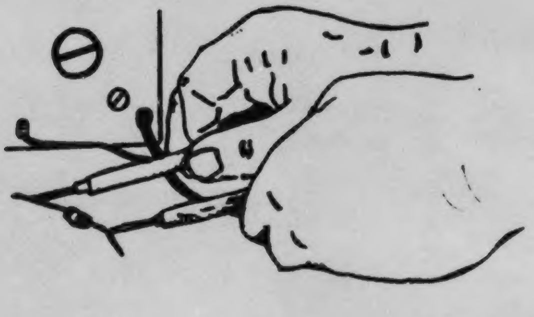
   A. Put on safety glasses

   B. Select highest ohm scale

   C. Zero meter

   D. Touch meter probes to resistor leads (Figure 1)

FIGURE 1



E. Read the resistance on the ohmmeter scale

F. Select R x 1 scale

G. Rezero meter

H. Have the instructor check your work

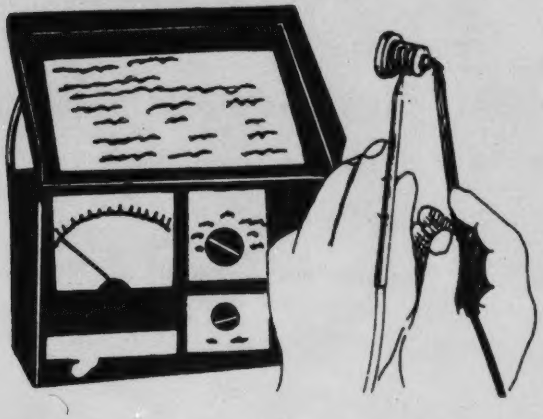
I. Check a plug type fuse

J. Touch one ohmmeter probe to outer metallic portion

K. Touch the ohmmeter probe to the button on the bottom (Figure 2)

(NOTE: Never check a fuse with an ohmmeter in a complete circuit.)

FIGURE 2



L. If the needle swings to zero the fuse is good

M. If the needle stays at infinity the fuse is not good

N. Touch the ohmmeter leads to each end of a cartridge type fuse

(NOTE: A good or bad cartridge fuse will be indicated in the same manner as the plug fuse was.)

O. Have instructor check your work

P. Turn ohmmeter to the "off" position or to the highest AC voltage range

Q. Put away tools and materials

ELECTRICAL TEST INSTRUMENTS
UNIT III

JOB SHEET #3--USE A WATTMETER

I. Tools and materials

A. Wattmeter

B. Safety glasses

C. Power consuming device

II. Procedure

A. Put on safety glasses

B. Read instructions supplied with wattmeter if available

C. Select the proper voltage

D. Connect the wattmeter to line voltage

E. Select the highest wattage scale

F. Connect current consuming device to wattmeter

G. Have instructor check

H. Start the current consuming device

I. Record starting wattage

J. Allow unit to run a few minutes while the wattage levels out

K. Select wattage scale that will allow for the easiest reading

L. Record running wattage

M. Obtain full load amperage from units name plate

N. Divide the voltage into the wattage to obtain the F.L.A.

(NOTE: Remember watts law is primarily for DC power, but for our purposes the power factor is generally close enouch to one that it can be used for AC power.)

O. Use an ammeter to check your answer

(NOTE: The use of the ammeter is covered in Job Sheet #4 of this unit.)

P. Have instructor check

Q. Put away meter and materials

ELECTRICAL TEST INSTRUMENTS
UNIT III

JOB SHEET #4--USE AN AMMETER

I. Tools and materials

A. Clamp on ammeter

B. Safety glasses

C. Circulation pump (1/2 HP 115 volt)

(NOTE: Pump must have water in it at all times to prevent damage to seals.)

II. Procedure

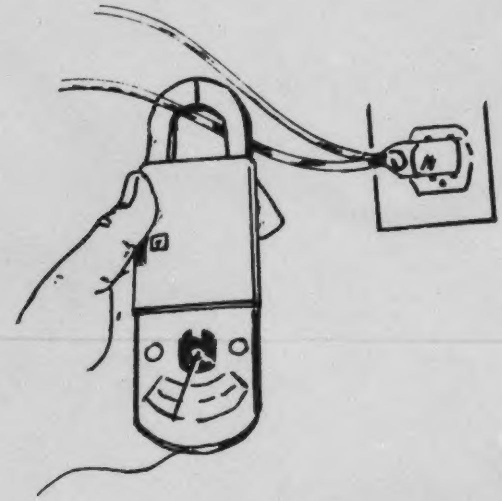
A. Put on safety glasses

B. Select highest amperage scale

C. Clamp ammeter around one conductor of the line cord (Figure 1)

(NOTE: Placing the ammeter around two conductors of single-phase power will cancel out the amperage reading.)

FIGURE 1



D. Start the pump motor

E. Record starting amperage

(NOTE: Starting amperage will only last an instant.)

F. Allow the pump motor to run

G. Record running amperage

H. Check F.L.A. on name plate

I. Compare the name plate amperage to the ammeter reading

J. Have instructor check

K. Put away meter and materials

ELECTRICAL TEST INSTRUMENTS
UNIT III

JOB SHEET #5--USE A CAPACITOR ANALYZER

I. Tools and materials

  A. Safety glasses

  B. Capacitor analyzer

  C. Bleed resistor

  D. Run capacitors

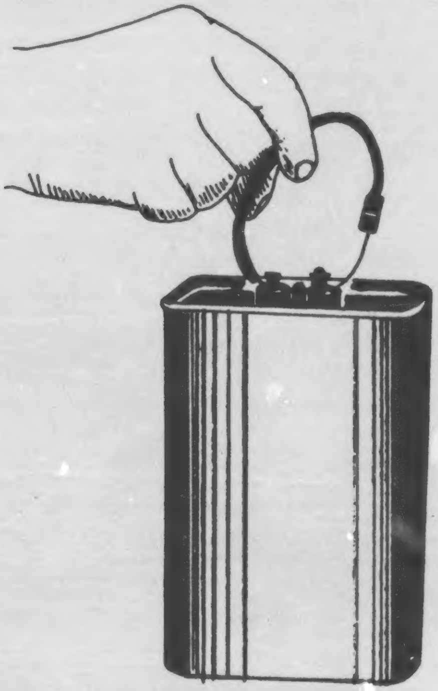
II. Procedure

  A. Put on safety glasses

  B. Discharge capacitor with bleed resistor (Figure 1)

  (NOTE: A bleed resistor should be used to discharge capacitors. Some capacitors are internally fused and shorting them with a screwdriver would ruin them.)

FIGURE 1



C. Read instructions on the use of the analyzer

(CAUTION: A shield should be placed between the capacitor and the individual doing the testing in case of a possible explosion.)

D. Check capacitor for opens

E. Check capacitor for grounds

F. Check microfarad capacity of capacitor

G. Check several different capacitors

H. Record the condition of each capacitor

I. Have instructor observe the capacitor checking procedure

J. Put away capacitor analyzer and capacitors

ELECTRICAL TEST INSTRUMENTS
UNIT III

JOB SHEET #6--TEST A CAPACITOR WITH AN OHMMETER

I. Tools and materials

   A. Safety glasses

   B. Ohmmeter with an R x 10K scale or above

   C. Bleed resistor

   D. Run capacitors

   E. Start capacitors

II. Procedure

   A. Put on safety glasses

   B. Discharge capacitor with bleed resistor

   (NOTE: Capacitors must be discharged before they can be checked with an ohmmeter to prevent damage to the meter.)

   C. Touch meter leads to capacitor terminals

   (NOTE: If the capacitor has a permanent bleed resistor connected to the terminals one side of it must be disconnected.)

   D. Watch for one of the following indications of the condition of the capacitor:

      1. Good--Needle will swing towards zero and then slowly return to infinity

      2. Shorted--Needle will swing toward zero and remain there

      3. Open--Needle will stay at infinity

      4. Leaky--Needle will swing towards zero and then return to a definite resistance and stay there

      5. Grounded run capacitor--Touch one meter lead to an unpainted spot on the metal can and the other lead to each terminal; any needle movement indicates a defective capacitor

E. Make a second check by reversing the leads at the capacitor terminals

F. Write down the condition of each capacitor

G. Have the instructor observe your work

H. Put away meter and materials

ELECTRICAL TEST INSTRUMENTS
UNIT III

NAME ______________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Main power supply

_____b. To align meter needle over zero on the ohm scale

_____c. Limits of a particular portion of a meter

_____d. Insulated ends on a test instrument's leads that are held while checking a circuit

_____e. To adjust a meter so that the needle is properly aligned to the proper set point on the scale

_____f. Complete circuit in which current can flow

_____g. Total current a device draws when it is running fully loaded

_____h. Extreme end of the ohm scale; designated by ∞

_____i. Amperage a motor would draw when the rotor is not turning with power applied

_____j. Resistor connected between capacitor terminals to discharge the capacitor for testing, generally a-20,000 ohm 2 watt carbon resistor

1. Full load amperage (F.L.A.)
2. Line voltage
3. Zero
4. Range
5. Probes
6. Calibrate
7. Locked rotor amperage (L.R.A.)
8. Infinity (infinite resistance)
9. Continuity
10. Bleed resistor

2. List six safety rules pertaining to electrical test instruments.

a.

b.

c.

d.

e.

f.

3. List five general rules for the protection of electrical test instruments.

a.

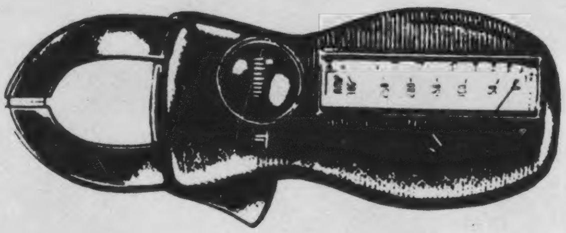
b.

c.

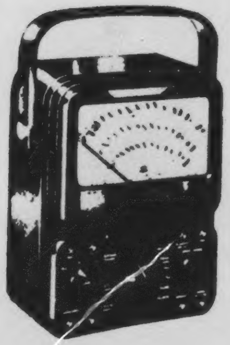
d.

e.

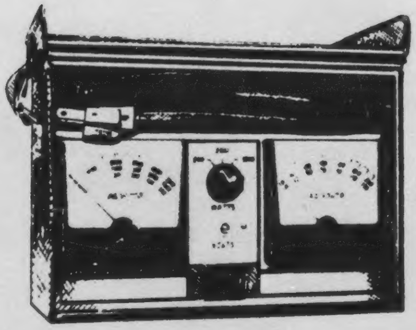
4. Identify the electrical test instruments.



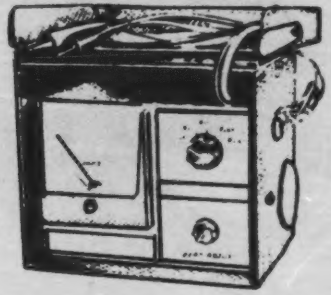
a. ______________________________



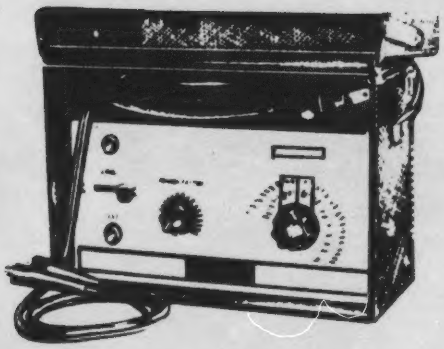
b. ______________________________



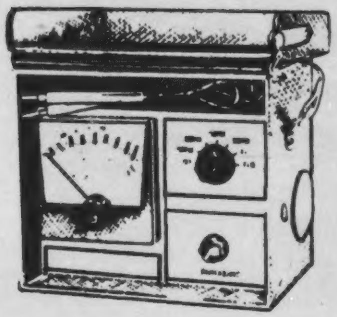
c. ______________________________



d. ______________________________



e. ______________________________



f. ______________________________

5. Match the meters on the right to the correct applications.

_____a. Measures line voltage; measures voltage drop at the load; measures low voltage; indicates open components

_____b. AC voltmeter; DC voltmeter; ohmmeter; milliammeter

_____c. Indicates line voltage; indicates starting watts; indicates running watts

_____d. Measures capacitance value; measures power factor; indicates open capacitors; indicates shorted capacitors; indicates leaky capacitors

_____e. Checks for a path for current flow; checks for resistance to current flow; determines motor windings; checks for shorts and grounds; checks capacitors

_____f. Checks starting amperage; checks running amperage; checks locked rotor amperage

1. Ohmmeter
2. Capacitor analyzer
3. Voltmeter
4. Wattmeter
5. Multimeter
6. Ammeter

6. List two steps for reading a meter scale.

a.

b.

7. Match the statements on the right to the correct applications on the left.

a. Open circuit

1)_____

2)_____

b. Short circuit

1)_____

2)_____

a. May not cause a fuse to blow or breaker to trip

b. Second most frequent circuit problem

c. No path for current flow

d. Circuit that has a lower resistance than intended

c. Grounded circuit

1)_____

2)_____

e. A high resistance path that current may take to a common ground

f. Most frequent circuit problem

8. Describe the procedure for zeroing the ohmmeter.

a.

b.

c.

d.

e.

9. Demonstrate the ability to:

a. Read a voltmeter scale.

b. Read an ammeter scale.

c. Read an ohmmeter scale.

d. Use a voltmeter.

e. Use an ohmmeter.

f. Use a wattmeter.

g. Use an ammeter.

h. Use a capacitor analyzer.

i. Test a capacitor with an ohmmeter.

(NOTE: If the above activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

ELECTRICAL TEST INSTRUMENTS
UNIT III

ANSWERS TO TEST

1. a. 2
   b. 3
   c. 4
   d. 5
   e. 6
   f. 9
   g. 1
   h. 8
   i. 7
   j. 10

2. Any six of the following:
   a. Stand on dry, nonconductive surfaces when testing live circuits
   b. Be sure the power is off when checking a circuit with an ohmmeter
   c. Do not use meter leads with defective probes
   d. Do not have both hands in a high voltage cabinet
   e. Do not touch metal cabinet or other grounded material
   f. Wear eye protection
   g. Use fuse pullers
   h. Do not assume that the power is off
   i. Discharge capacitors with a bleed resistor before removing or testing

3. Any five of the following:
   a. Keep stored in proper cases
   b. Avoid bumping or jolting
   c. Use only for intended purpose
   d. Use within meter range limits
   e. Avoid exposure to extreme temperatures
   f. Keep clean

g. Keep dry

h. Set meter in highest range prior to taking reading

4. a. Ammeter

b. Multimeter

c. Wattmeter

d. Hermetic analyzer

e. Ohmmeter

f. Capacitor analyzer

g. Voltmeter

5. a. 3

b. 5

c. 4

d. 2

e. 1

f. 7

6. a. Read meter in the center two-thirds of the scale for greater accuracy

b. Count the number of graduations between the major divisions

7. Statements should include:

a. Open circuit

1) Most frequent circuit problem

2) No path for current flow

b. Short circuit

1) Second most frequent circuit problem

2) Electrical circuit that has a lower resistance than intended

c. Grounded circuit

    1) A high resistance path that current may take to a common ground

    2) May not cause a blown fuse or tripped circuit breaker

8. a. Select range

    b. Hold leads together

    c. Check to see that the needle moves to the extreme light

    d. Align the needle directly over "0" on the ohm scale

    e. Zero ohmmeter each time before using or when changing ranges

9. Performance skills evaluated to the satisfaction of the instructor

INTRODUCTION TO ELECTRIC MOTORS
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to list safety rules that apply to electric motors and discuss magnetism. The student should also be able to list types of single-phase motors and identify motor parts. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

(NOTE: The student must score 100 percent on the safety section of the test.)

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with electric motors to the correct definitions.
2. List six safety rules pertaining to working with electric motors.
3. Discuss magnetism.
4. Discuss magnets in an induction type motor.
5. List four types of single-phase motors.
6. Identify the parts of an open drive motor.
7. Identify two common types of motor mounts.
8. Match statements on the application of motor enclosures.
9. List twelve items of information provided on a motor data plate.
10. List two causes of motor problems.
11. List two remedies for motor problems.
12. Demonstrate the ability to: Give the remedy to motor problems

INTRODUCTION TO ELECTRIC MOTORS
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information, assignment, and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Obtain films or slide sets on electric motor fundamentals.

   H. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete assignment and job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Attraction and Repulsion of Charges

      2. TM 2--Electric Motor

    3. TM 3--Parts of an Open Drive Motor
    4. TM 4--Types of Motor Mounts
    5. TM 5--Motor Data Plate

D. Assignment Sheet #1--Give the Remedy to Motor Problems

E. Answers to assignment sheet

F. Test

G. Answers to test

II. References:

A. Schweitzer, Gerald. Basics of Fractional Horsepower Motors and Repair. Rochelle Park, New Jersey: Hayden Book Co., February 1960.

B. Turner, J. Howard. How Electric Motors Start and Run. Athens, Georgia: American Association for Vocational Instructional Materials, 1973.

C. Parady, W. Harold; Turner, J. Howard; and Wren, James E. Electric Motors. Athens, Georgia: American Association for Vocational Instructional Materials, January 1972.

INTRODUCTION TO ELECTRIC MOTORS
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Poles--Soft iron, laminated portion of the stator which the insulated wire is wound around

B. Stator--Stationary section that consists of the windings and core which form the electromagnet that produces the magnetic field causing the motor to turn

C. Rotor--Rotating section which rotates within the stator of a motor

D. Induction motor--Alternating current motor in which the stator is connected to the power source; this induces current into a secondary winding called the rotor

E. NEMA (National Electrical Manufacturer's Association)--Establishes certain voluntary standards relating to motors

F. Resilient mount--Rubber support on each end of the motor which cushions the motor base from vibrations

G. Rigid mount--Mounting brackets are permanently attached to the motor frame

H. Slip--Difference between the synchronous speed of a motor and the speed at which it operates

I. Shunt--A low resistance conductor which connects two parts of a circuit in parallel

II. Safety rules that apply to electric motors

A. Don't underestimate the potential danger of a 110 VAC motor

B. Do not work on live circuits except when absolutely necessary

C. Never bypass electrical protective devices on electric motors

D. Do not leave motor terminals exposed

E. Stand on dry nonconductive surfaces when working on live circuits

F. Check all circuits for voltage before doing any service work

G. Tag and lock all electrical disconnects when working on live circuits

H. Use proper size electrical cord

I. Wear eye protection

J. Do not touch moving parts

K. Ground all electric motors

III. Magnetism (Transparency 1)

A. Poles

1. North

2. South

B. Pole movement

1. Like poles repel

2. Unlike poles attract

C. Electromagnet

1. Insulated wire wound around a soft iron core

2. Essential in supplying the magnetic field for rotor rotation

IV. Magnets in an induction type motor (Transparency 2)

A. Stator

(NOTE: The stator becomes an electromagnet which reverses polarity 120 times a second on 60 Hz current.)

1. Laminated soft iron

2. Wound with insulated wire

(NOTE: This wire is referred to as magnetic wire and it has a thin baked-on enamel coating.)

B. Rotor
   1. A permanent magnet
   2. Turns seeking an opposite pole
   3. Push-pull action of attracting and repelling keeps rotor turning
   4. Automatically adjusts to the synchronous speed

V. Types of single-phase motors
   A. Split-phase
   B. Shaded-pole
   C. Capacitor start induction run (C.S.I.R.)
   D. Capacitor start capacitor run (C.S.R.)
   E. Permanent split capacitor (P.S.C.)

VI. Parts of open drive motor (Transparency 3)
   A. Stator assembly
      1. Stator windings
      2. Frame (motor body)
   B. Rotor
   C. End bells
   D. Overload
   E. Centrifugal control
   F. Starting switch
   G. Assembly bolts

VII. Common types of motor mounts (Transparency 4)
   A. Cradle mount
   B. Rigid mount

VIII. Motor enclosures

A. Open

1. Air openings in frame and/or end bells

2. Used where dirt, dust, and moisture are not a problem

B. Open-drip proof

1. Air openings are in frame with shrouds to prevent moisture from entering

2. Used where dripping moisture may be a problem

C. Submersible

1. Totally enclosed and sealed

2. Used where it is necessary for the motor to be submersed in water or some other fluid

IX. Information provided on motor data plate (Transparency 5)

(NOTE: Never remove the data plate from a motor.)

A. Model number

B. Serial number

C. Type

D. Horsepower rating (Hp.)

E. Phase (Ph.)

(NOTE: This refers to single-phase or three-phase current.)

F. Hertz (cycle)

G. Voltage

H. Full load amperage (F.L.A.)

I. Locked rotor amperage (L.R.A.)

J. Service factor (S.F.)

Example: An S.F. of 1.15 means a motor can be loaded 15% greater than its rated horsepower for short periods of time.

K. R.P.M.

   (NOTE: This is the revolutions per minute that a motor shaft will turn.)

L. Frame

   (NOTE: This will be NEMA designated number indicating that the body of the motor is of a certain size.)

M. Temperature rise

   (NOTE: This is the allowable motor temperature increase and is usually indicated in degrees Celsius (^{O}C.)

N. Duty rating

X. Motor problems and causes

A. Failure to start

1. Blown fuse or open circuit breaker
2. Open wiring circuit
3. Incorrect power line connections
4. Excessive load
5. Excessive end play
6. Seized or worn bearings
7. Open overload

B. Overheating of bearings

1. Motor bearings need oil
2. Dirty oil
3. Oil not reaching shaft
4. Excessive grease or oil
5. Rough bearing surface
6. Misalignment of shaft and bearing
7. Excessive end thrust

C. Overheating of motor

1. Obstruction of ventilating system
2. Overloading
3. Rotor dragging on stator
4. Incorrect voltage
5. High ambient location

D. Stator burned out

1. Worn bearings
2. Moisture
3. Overloading
4. Defective start mechanism

XI. Motor problems and remedies

A. Failure to start

1. Replace or reset fuse
2. Check supply voltage with motor underload

   (NOTE: Supply voltage should be within 10% of motor data plate voltage.)
3. Check motor wiring with ohmmeter
4. Remove load from motor and try to start

B. Overheating of bearings

1. Use recommended nondetergent motor bearing oil
2. Move motor shaft by hand to check for:
   a. End play
   b. Side play
   c. Bearing tightness

C. Overheating of motor

1. Clean motor

2. Check full load amperage

3. Check for correct voltage

   (NOTE: This voltage check should be made with the motor underload and at the motor terminals.)

4. Check for loose bearings

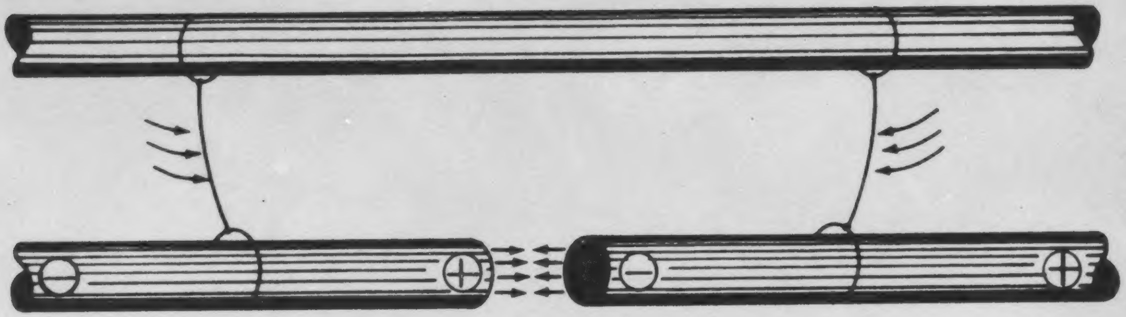
5. Check for tight bearings

D. Stator burned out

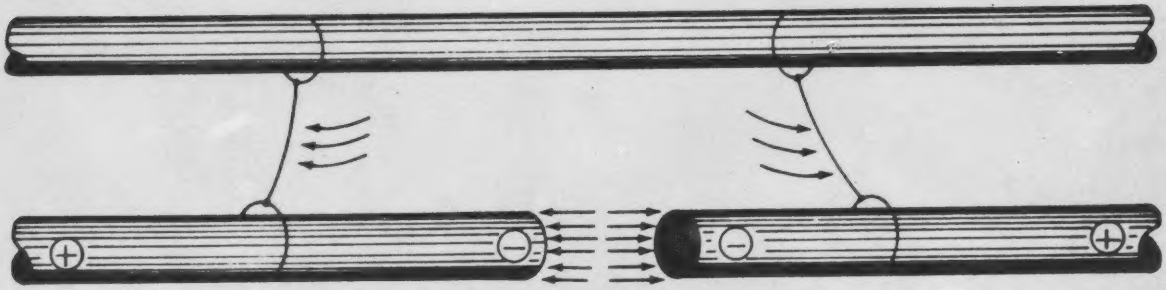
   1. Have stator rewound

   2. Replace complete motor

Attraction And Repulsion Of Charges

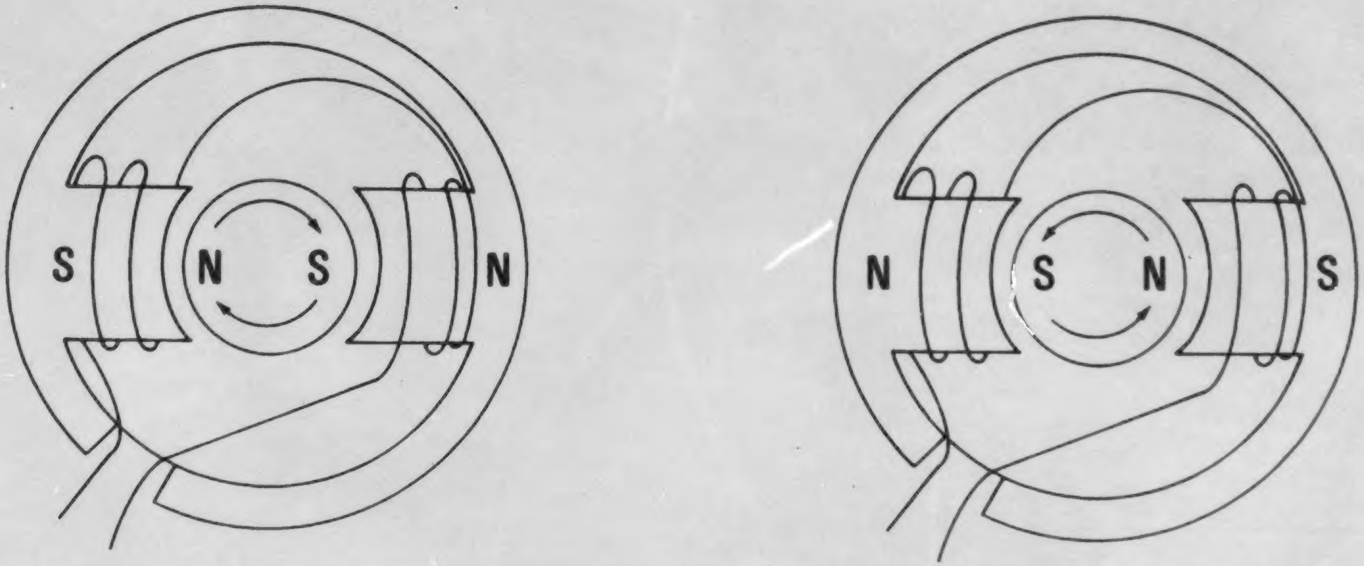


⊕ ⊖ Charges Attract



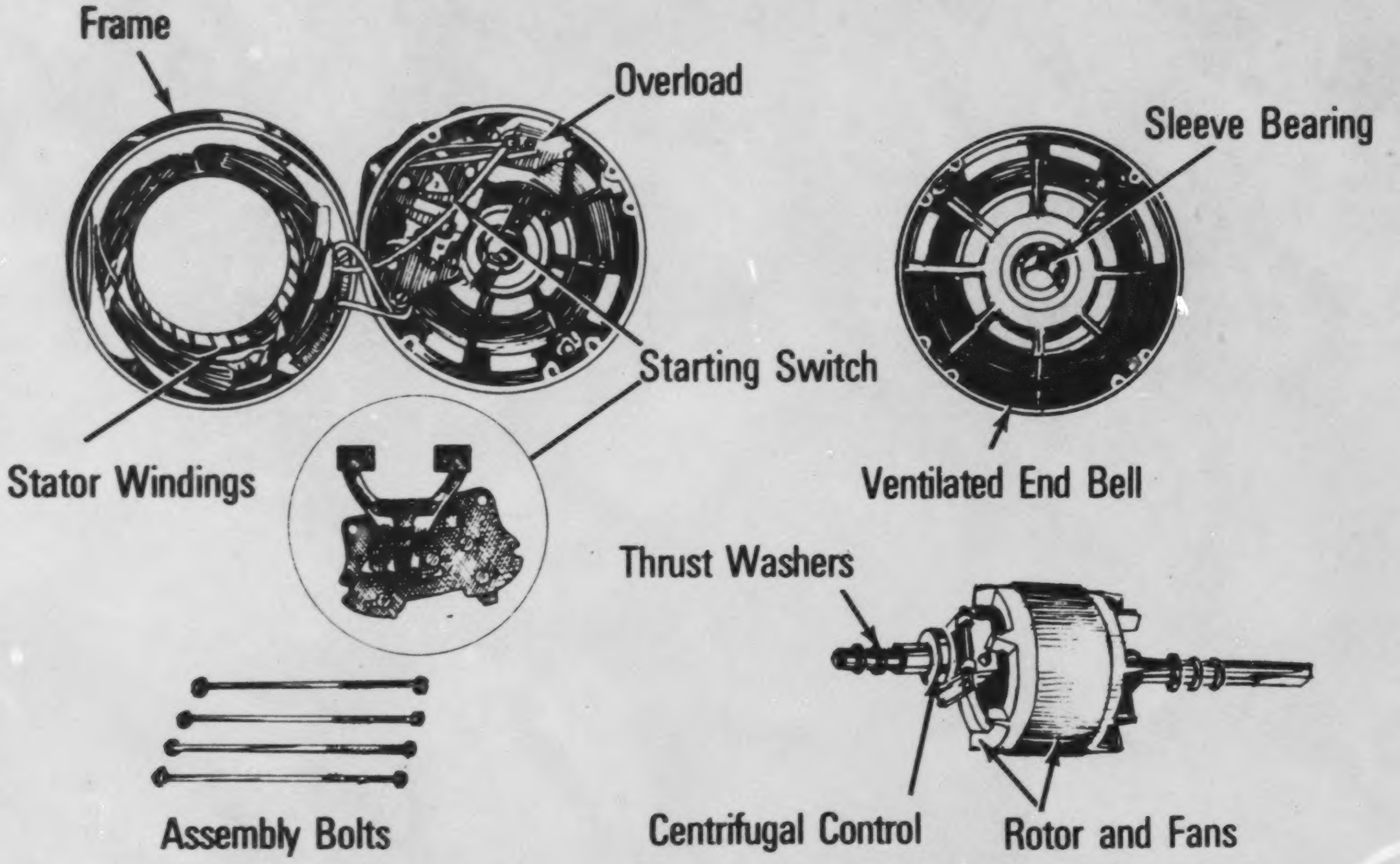
⊕ ⊕ Or ⊖ ⊖ Charges Repel

Electric Motor



Reversing Direction Of Current Flow Reverses Magnetic Polarity

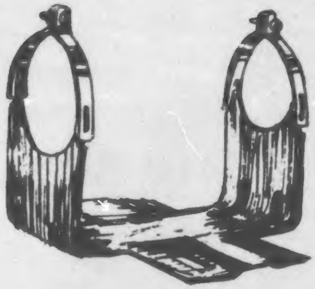
Parts Of An Open Drive Motor



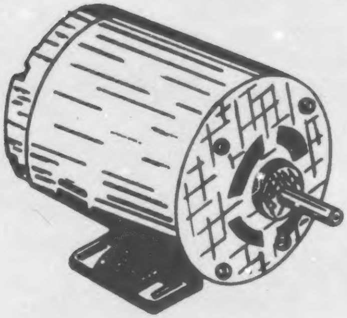
TM 3

S-17-C

Types Of Motor Mounts

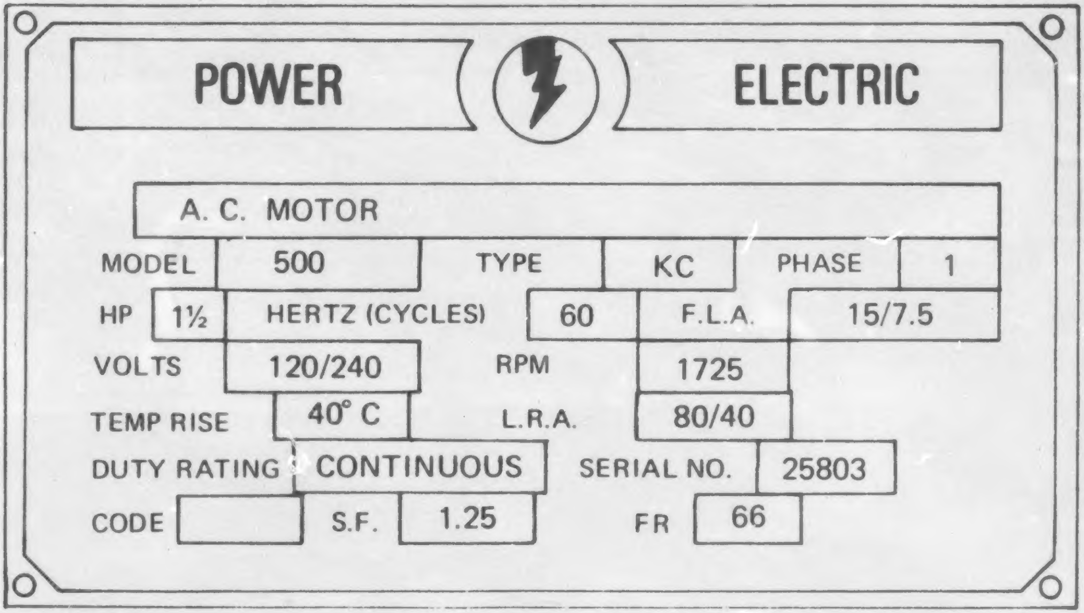


Cradle



Rigid Mount

Motor Data Plate



POWER ELECTRIC

A. C. MOTOR

MODEL	500	TYPE	KC	PHASE	1
HP	1½	HERTZ (CYCLES)	60	F.L.A.	15/7.5
VOLTS	120/240	RPM	1725		
TEMP RISE	40° C	L.R.A.	80/40		
DUTY RATING	CONTINUOUS	SERIAL NO.	25803		
CODE		S.F.	1.25	FR	66

INTRODUCTION TO ELECTRIC MOTORS
UNIT I

ASSIGNMENT SHEET #1--GIVE THE REMEDY TO MOTOR PROBLEMS

In the following situations the problems and the causes are stated; give the remedy (or remedies) for each situation.

1. Motor fails to start and an open circuit breaker was found to be the cause.

2. Motor is overheating and the ventilation openings in the end bells were found to be clogged.

3. Motor is excessively noisy due to worn bearings.

4. Motor is overheating due to being overloaded.

INTRODUCTION TO ELECTRIC MOTORS
UNIT I

ANSWERS TO ASSIGNMENT SHEET

1. Reset breaker or replace fuse.

2. Electric motors must be kept clean and dry, necessitating periodic inspections. Dust is removed, and ventilating openings must not be covered by other obstructions.

3. A dry or slightly worn bearing results in slip frequency noise or purr. Oil the bearings properly (periodically as required) or replace.

4. Check driven device to make sure it does not bind. Check application by measuring input watts and amps under normal operating conditions.

2. List six safety rules pertaining to working with electric motors.

   a.

   b.

   c.

   d.

   e.

   f.

3. Discuss magnetism.

   a. Poles

      (1) ____________________

      (2) ____________________

   b. Pole movement

      (1) ____________________

      (2) ____________________

   c. Electromagnet

      (1) ____________________

      (2) ____________________

4. Discuss magnets in an induction type motor.

   a. Stator

      (1) ____________________

      (2) ____________________

   b. Rotor

      (1) ____________________

      (2) ____________________

INTRODUCTION TO ELECTRIC MOTORS
UNIT I

NAME________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Stationary section that consists of the windings and core which form the electromagnet that produces the magnetic field causing the motor to turn

_____b. Alternating current motor in which the stator is connected to the power source; this induces current into a secondary winding called the rotor

_____c. Soft iron, laminated portion of the stator which the insulated wire is wound around

_____d. Rotating section which rotates within the stator of a motor

_____e. Establishes certain voluntary standards relating to motors

_____f. Difference between the synchronous speed of a motor and the speed at which it operates

_____g. Rubber support on each end of the motor which cushions the motor base from vibrations

_____h. Mounting brackets are permanently attached to the motor frame

1. Rotor
2. Poles
3. Induction motor
4. Stator
5. NEMA (National Electrical Manufacturer's Association)
6. Slip
7. Resilient mount
8. Rigid mount

5. List four types of single-phase motors.

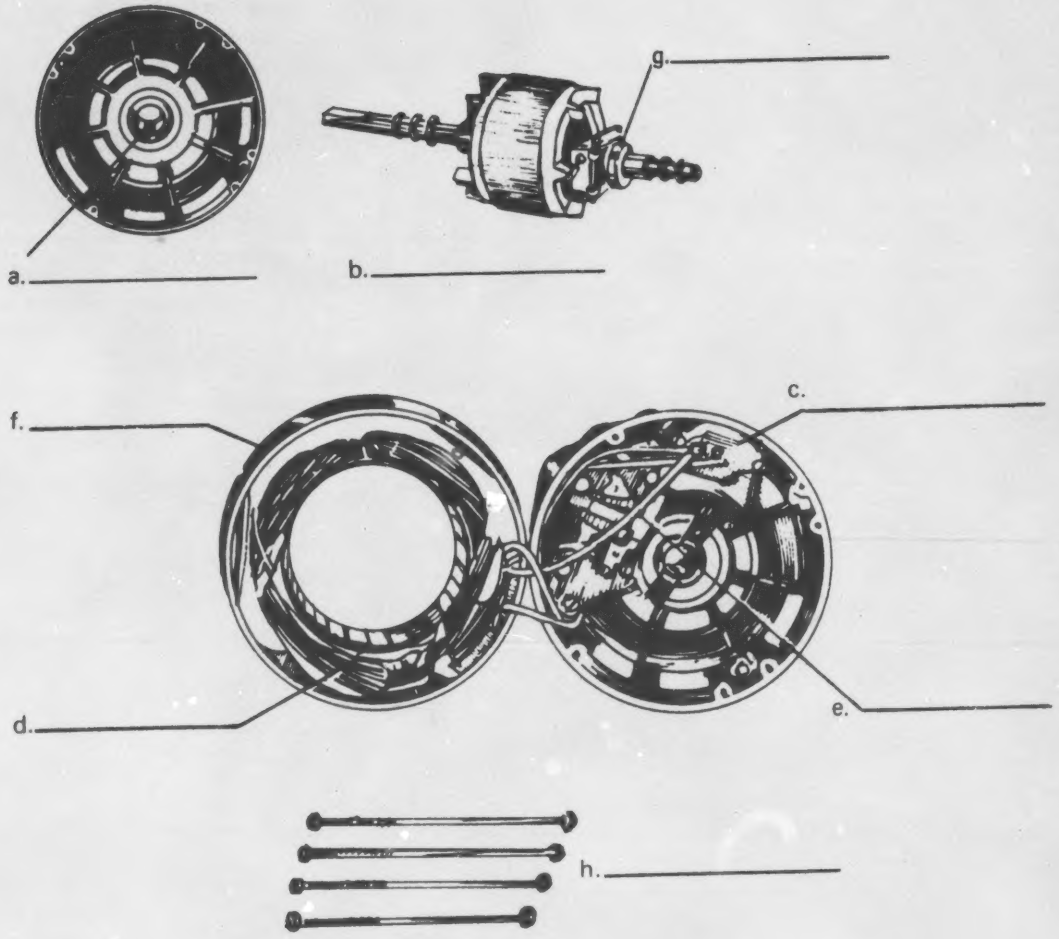
   a.

   b.

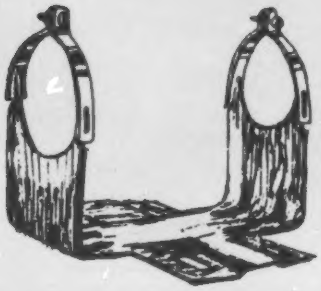
   c.

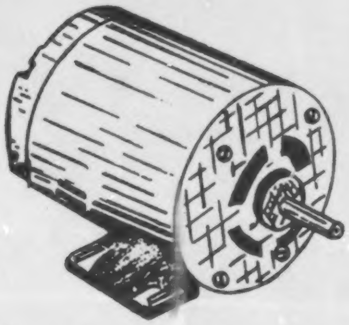
   d.

6. Identify the parts of an open drive motor.



7. Identify two common types of motor mounts.





a. ____________________   b. ____________________

8. Match the statements on the right to the proper application of motor enclosures.

A. Open type

1) __________

2) __________

B. Open-drip proof

1) __________

2) __________

C. Submersible

1) __________

2) __________

a. Used where dripping moisture may be a problem

b. Air openings in frame and/or end bells

c. Used where dirt, dust, and moisture are not a problem

d. Air openings are in the frame with shields to prevent moisture from entering

e. Totally enclosed and sealed

f. Used where it is necessary for the motor to be submersed in water or other fluid

9. List twelve items of information provided on a motor data plate.

a. ____

b. ____

c. ____

d. ____

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

i. ______________________________

j. ______________________________

k. ______________________________

l. ______________________________

10. List two causes for each of the following motor problems.

    a. Failure to start

        1) ______________________________

        2) ______________________________

    b. Overheating of bearings

        1) ______________________________

        2) ______________________________

    c. Overheating of motor

        1) ______________________________

        2) ______________________________

    d. Stator burned out

        1) ______________________________

        2) ______________________________

11. List two remedies for each of the following motor problems.

    a. Failure to start

        1) ______________________________

        2) ______________________________

b. Overheating of motor

1) ____

2) ____

c. Stator burned out

1) ____

2) ____

12. Give the remedy to motor problems.

INTRODUCTION TO ELECTRIC MOTORS
UNIT I

ANSWERS TO TEST

1. a. 6
   b. 3
   c. 2
   d. 1
   e. 8
   f. 9
   g. 10
   h. 11

2. Any six of the folling:
   a. Don't underestimate the potential danger of a 110 VAC circuit
   b. Do not work on live circuits except when absolutely necessary
   c. Never bypass electrical protective devices
   d. All electrical wiring must be well insulated
   e. Stand on dry nonconductive surfaces when working on live circuits
   f. Check all circuits for voltage before doing any service work
   g. Tag and lock all electrical disconnects when working on live circuits
   h. Use proper size electrical cord
   i. Wear eye protection
   j. Do not touch moving parts

3. Discussion should include:
   a. Poles
      1) North
      2) South

- b. Pole movement
    - 1) Like poles repel
    - 2) Unlike poles attract
- c. Electromagnet
    - 1) Insulated wire wound around a soft iron core
    - 2) Essential in supplying the magnetic field for rotor rotation

4. Discussion should include:
    - a. Stator
        - 1) Laminated soft iron
        - 2) Wound with insulated wire
    - b. Rotor
        - 1) A permanent magnet
        - 2) Push-pull action of attracting and repelling keeps rotor turning

5. Any four of the following:
    - a. Split-phase
    - b. Shaded-pole
    - c. Capacitor start induction run (C.S.I.R.)
    - d. Capacitor start capacitor run (C.S.R.)
    - e. Permanent split capacitor (P.S.C.)

6. a. End bell
    - b. Rotor
    - c. Overload
    - d. Stator windings
    - e. Starting switch
    - f. Frame (motor body)
    - g. Centrifugal control
    - h. Assembly bolts

7. a. Cradle mount
   b. Rigid mount

8. Discussion should include:
   - a. Open
     - 1) Air openings in frame and/or end bells
     - 2) Used where dirt, dust, and moisture are not a problem
   - b. Open-drip proof
     - 1) Air openings are in frame with shrouds to prevent moisture from entering
     - 2) Used where dripping moisture may be a problem
   - c. Submersible
     - 1) Totally enclosed and sealed
     - 2) Used where it is necessary for the motor to be submersed in water or some other fluid

9. Any twelve of the following:
   - a. Model number
   - b. Serial number
   - c. Type
   - d. Horsepower rating (Hp.)
   - e. Phase (Ph.)
   - f. Hertz (cycle)
   - g. Voltage
   - h. Full load amperage (F.L.A.)
   - i. Locked rotor amperage (L.R.A.)
   - j. Service factor (S.F.)
   - k. R.P.M.
   - l. Frame

m. Temperature rise

n. Duty rating

10. Any two of the following under each section:.

a. Failure to start

1) Blown fuse or open circuit breaker

2) Open wiring circuit

3) Incorrect power line connections

4) Excessive load

5) Excessive end play

6) Seized or worn bearings

7) Open overload

b. Overheating of bearings

1) Motor bearings need oil

2) Oil not reaching shaft

3) Excessive grease or oil

c. Overheating of motor

1) Obstruction of ventilating system

2) Overloading

3) Rotor dragging on stator

4) Incorrect voltage

5) High ambient location

d. Stator burned out

1) Worn bearings

2) Moisture

3) Overloading

4) Defective start mechanism

11. Any two of the following under each section:
    a. Failure to start
        1) Replace or reset fuse
        2) Check supply voltage with motor underload
        3) Check motor wiring with ohmmeter
        4) Remove load from motor and try to start
    b. Overheating of motor
        1) Clean motor
        2) Check full load amperage
        3) Check for correct voltage
        4) Check for loose bearings
        5) Check for tight bearings
    c. Stator burned out
        1) Have stator rewound
        2) Replace complete motor
12. Performance skills evaluated to the satisfaction of the instructor

SPLIT-PHASE MOTORS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify various components of split-phase motors and list windings and their characteristics. The student should also be able to match motor lead code number to color, wire a split-phase motor, and disassemble, inspect, clean, and reassemble a split-phase motor. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with split-phase motors to the correct definitions.
2. State the common horsepower range of split-phase motors.
3. List applications of split-phase motors.
4. List the two windings of a split-phase motor.
5. List the characteristics of the windings in a split-phase motor.
6. Discuss the purpose of the starting mechanism.
7. Identify the components of a split-phase motor.
8. Match start and run windings to the motor lead codes by NEMA.
9. Match code number to color code of motor leads.
10. Identify the directions of rotation.
11. Demonstrate the ability to:
    a. Wire a split-phase motor to 115 VAC power supply
    b. Reverse rotation of a split-phase motor
    c. Disassemble, inspect, clean, and reassemble a split-phase motor

SPLIT-PHASE MOTORS
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Disassemble a split-phase motor and place it on a display board.

   H. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Split-Phase Motors

      2. TM 2--Characteristics of Run and Start Windings

    3. TM 3--Schematic Diagram of a Split-Phase Motor
    4. TM 4--NEMA Motor Lead Color Code
    5. TM 5--Motor Wiring for Rotations

D. Job sheets

    1. Job Sheet #1--Wire a Split-Phase Motor to a 115 VAC Supply
    2. Job Sheet #2--Reverse Rotation of a Split-Phase Motor
    3. Job Sheet #3--Disassemble, Inspect, Clean, and Reassemble a Split-Phase Motor

E. Test

F. Answers to test

II. References:

A. Schweitzer, Gerald. Basics of Fractional Horsepower Motors and Repair. Rochelle Park, New Jersey: Hayden Book Co., Inc., 1960.

B. Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. Modern Refrigeration and Air Conditioning. Homewood, Illinois: Goodheart-Wilcox Co., 1975.

SPLIT-PHASE MOTORS
UNIT II

INFORMATION SHEET

I. Terms and definitions

  A. Torque--Twisting force created by a motor as it starts and runs

  B. Start winding--Winding in the electric motor that is used only briefly while the motor is starting

  C. Run winding--Winding of motor which has current flowing through it during normal operation of motor

  D. Split-Phase motor--Motor with two stator windings; while both windings are in use for starting, the starting winding is disconnected by centrifugal switch after motor attains approximately 75 to 85% of its speed and motor then operates on run winding only

II. Common horsepower range of split-phase motors--1/20 to 3/4

III. Applications of split-phase motors (Transparency 1)

  A. Fans

  B. Pumps

  C. Blowers

IV. Windings of split-phase motor

  A. Start

  B. Run

V. Characteristics of windings in split-phase motor (Transparency 2)

  A. Start Winding

    1. High resistance

    2. Small wire

    3. More turns

    4. Wound on top of run winding in pole slots

B. Run winding

1. Low resistance

2. Heavier wire

3. Fewer turns

4. Wound in bottom of pole slots

VI. Purpose of starting mechanism--Removes starting winding when motor reaches approximately 75 to 80% of its synchronous speed

VII. Components of split-phase motor (Transparency 3)

A. Overload (inherent motor protection)

B. Rotor

C. Centrifugal starting mechanism or relay

D. Starting winding

E. Run winding

VIII. National Electrical Manufacturer's Association (NEMA) motor lead codes for start and run windings (Transparency 4)

A. Start winding--T2 and T4

B. Run winding--T1 and T3

IX. Motor lead color code

A. T1--Red

B. T2--Blue

C. T3--Yellow

D. T4--Black

(NOTE: This color coding is typical and may vary in some specific motors.)

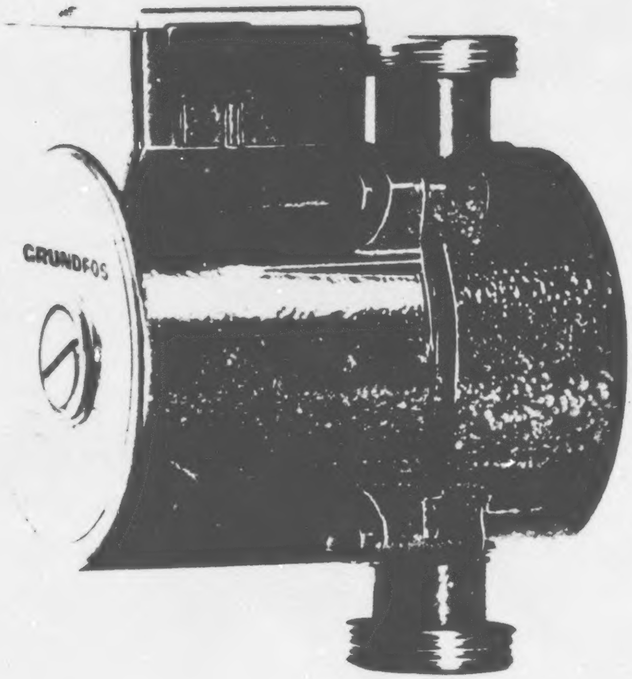
X. Directions of rotation (Transparency 5)

A. Counterclockwise

B. Clockwise

(NOTE: Motor rotation is determined from shaft end on some motors and opposite the shaft end on others.)

Split-Phase Motors



Courtesy of Grunfos Inc.

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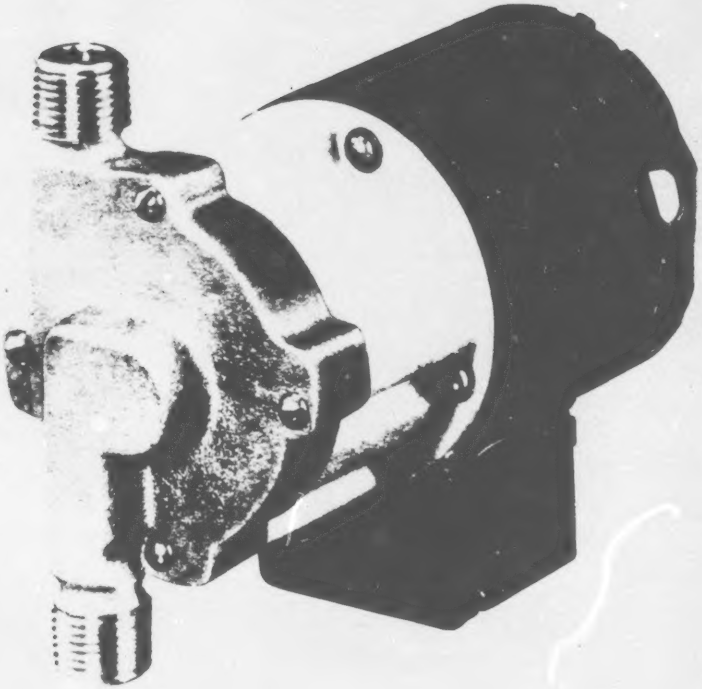


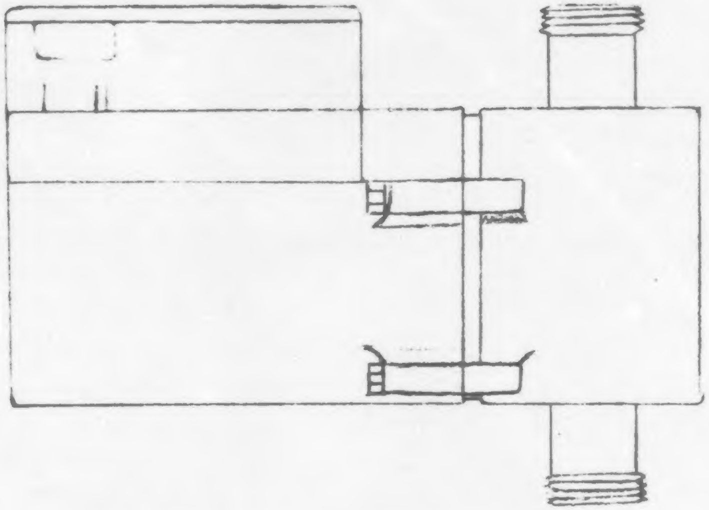
Courtesy of March Manufacturing

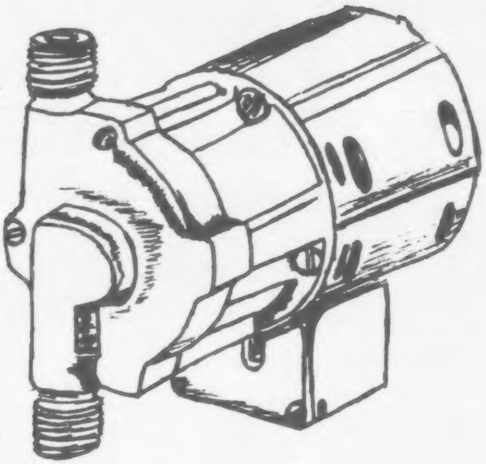
282

TM-1

S-45-C

Split-Phase Motors





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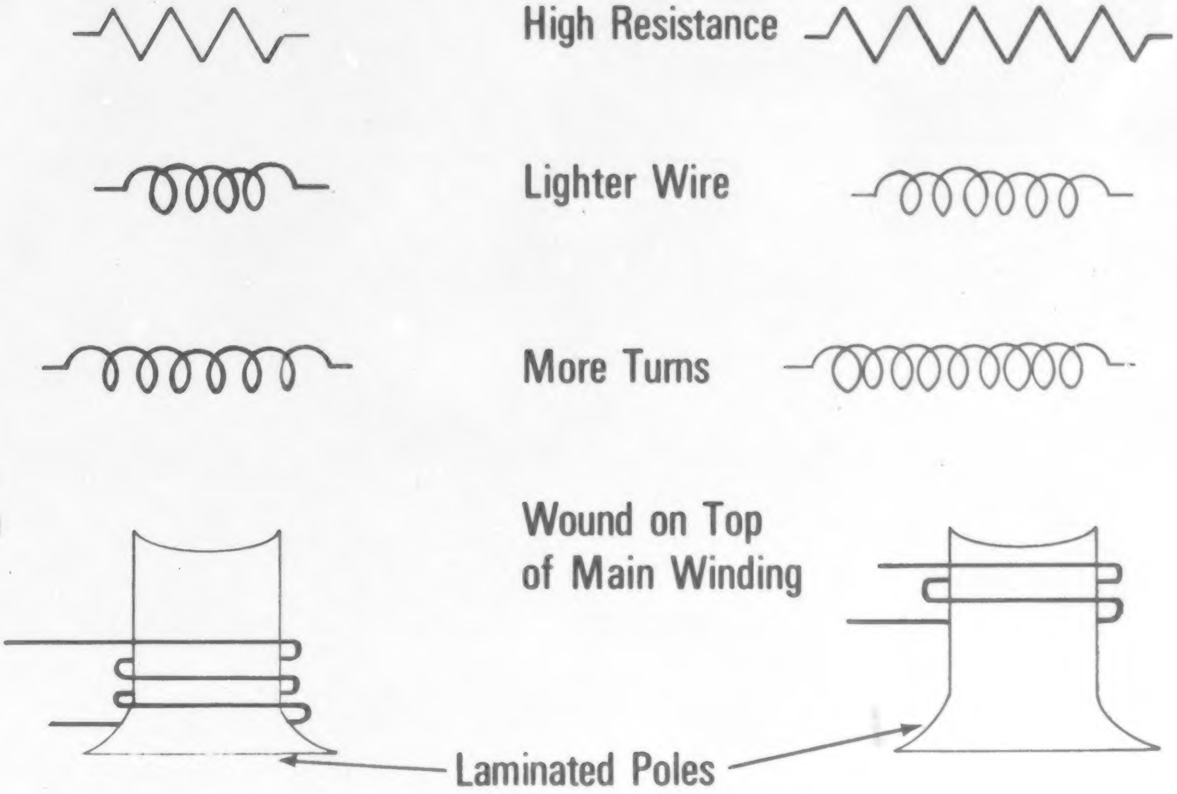
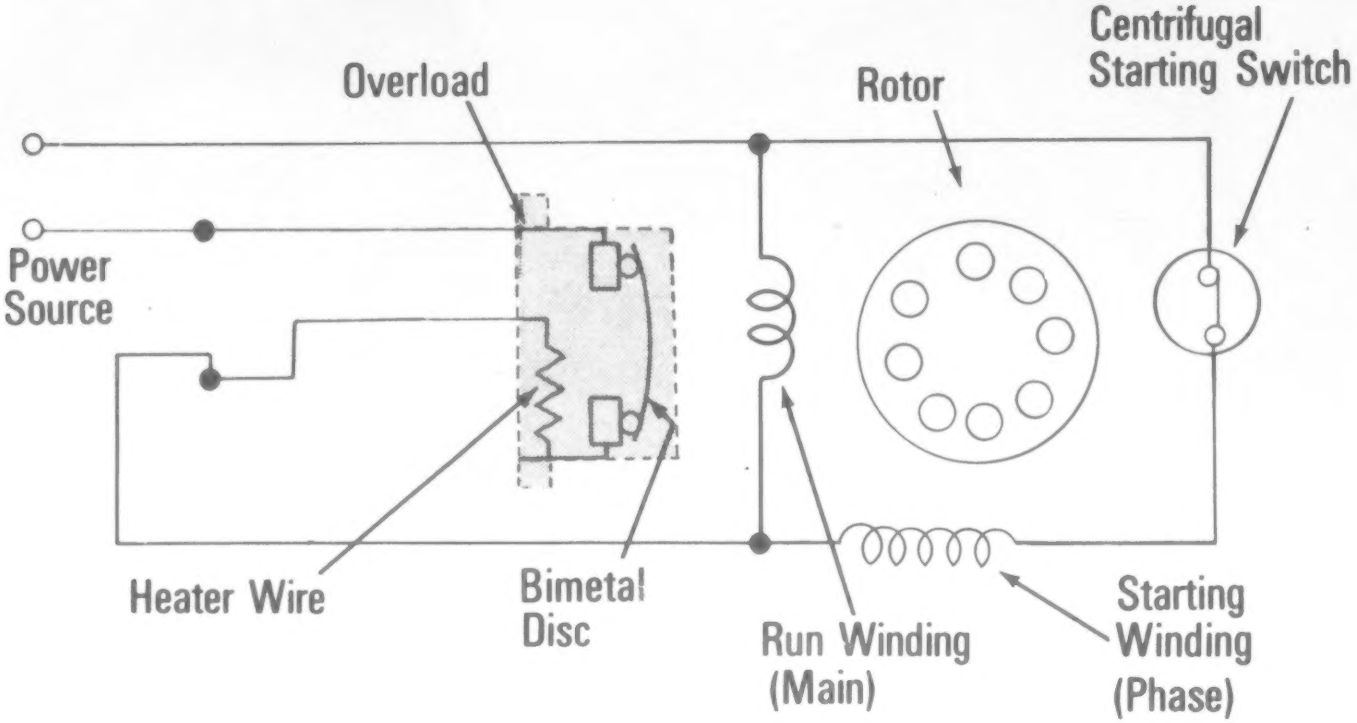
TM 1

Characteristics of Run and Start Windings

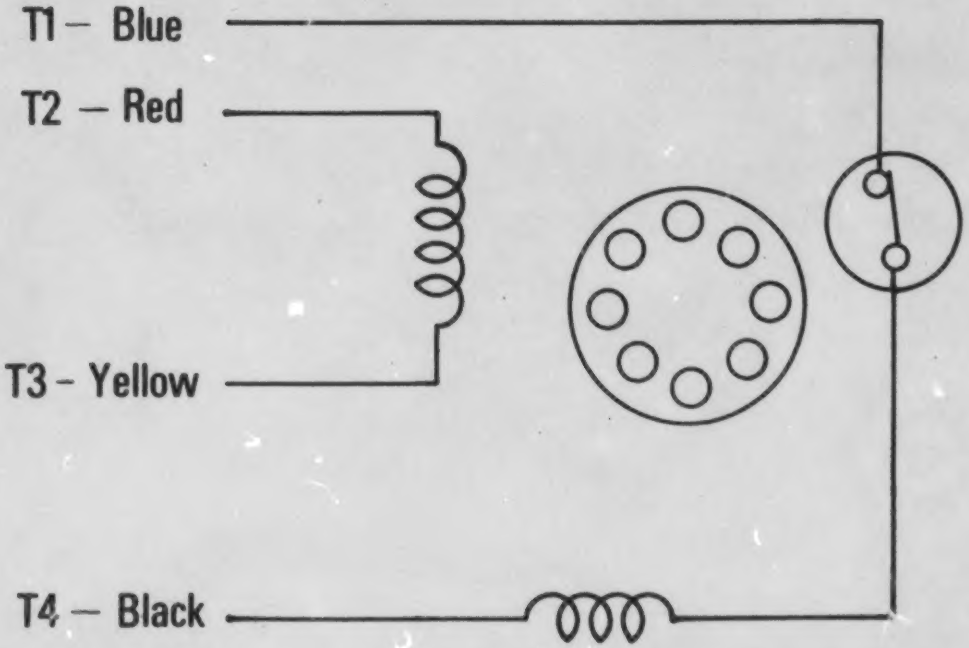


Run	Start
Low Resistance	High Resistance
Heavier Wire	Lighter Wire
Few Turns	More Turns
Wound in Bottom of Slots	Wound on Top of Main Winding

Schematic Diagram of a Split-Phase Motor

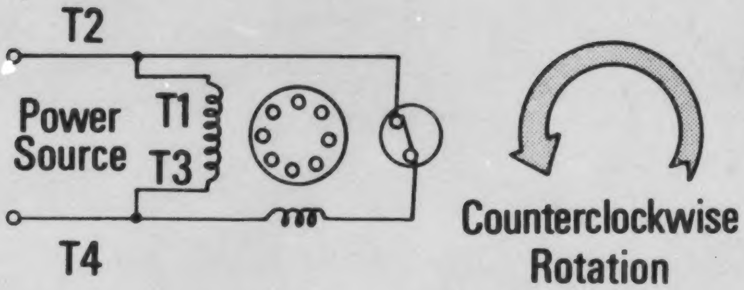


NEMA Motor Lead Color Code

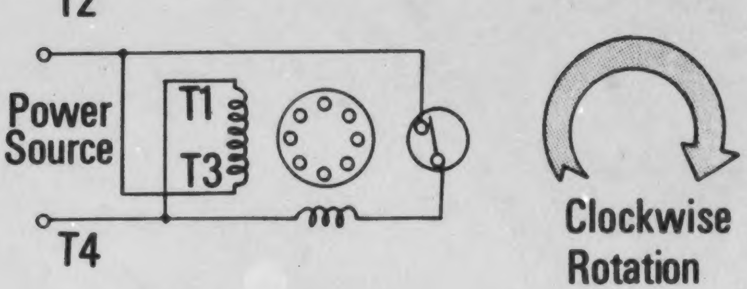


S-51-C

Motor Wiring for Rotations



Counterclockwise Rotation



Clockwise Rotation

(Note: On some motors the wiring is inaccessible.)

SPLIT-PHASE MOTORS
UNIT II

JOB SHEET #1--WIRE A SPLIT-PHASE MOTOR TO A 115 VAC POWER SUPPLY

I. Tools and materials

A. Ammeter

B. Voltmeter

C. 115 VAC split-phase motor

II. Procedures

A. Check to be sure all electrical power is disconnected

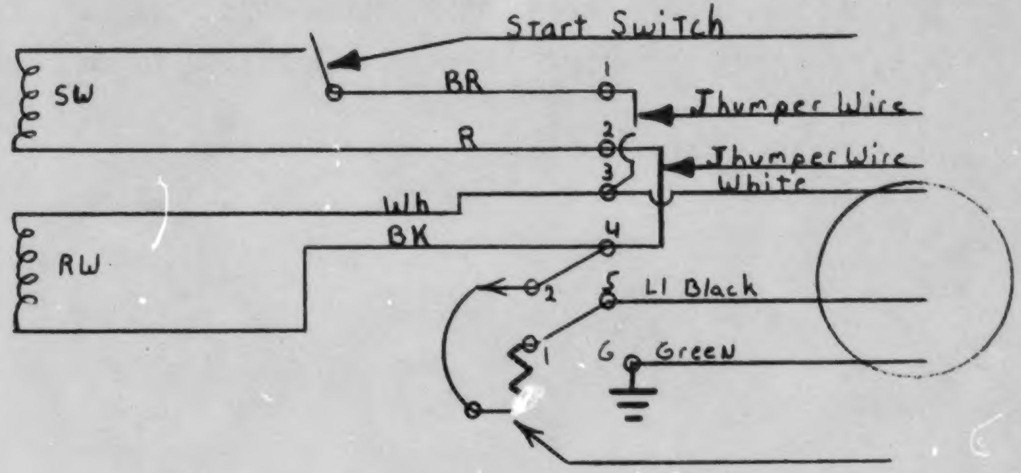


FIGURE 1

B. Connect a jumper between terminals 1 and 3

C. Connect a jumper between terminals 2 and 4

D. Connect the black L1 lead to terminal 5

E. Connect the white N lead to terminal 3

F. Connect the Green lead to the motor frame

(NOTE: This lead is often a bare conductor)

G. Place the voltmeter at 250 VAC or higher range

H. Clip the voltmeter leads to motor terminals 3 and 4

I. Place ammeter in highest range

J. Clamp ammeter around the L1 lead

K. Have the instructor inspect wiring

L. Turn on electrical power and start motor

M. Adjust test meters for most accurate readings

N. Record the following data

   1. Voltage_______________

   2. Running amps_______________

   3. Direction of rotation_______________

   (NOTE: Determine rotation facing shaft end of motor.)

O. Have instructor inspect project

P. Clean up and put away motor and tools

SPLIT-PHASE MOTORS
UNIT II

JOB SHEET #2--REVERSE ROTATION OF A SPLIT-PHASE MOTOR

I. Tools and materials

   A. Ammeter

   B. Voltmeter

   C. Split-phase motors

II. Procedures

   A. Check to be sure all electrical power is disconnected

   B. Connect L1 lead to terminal 5

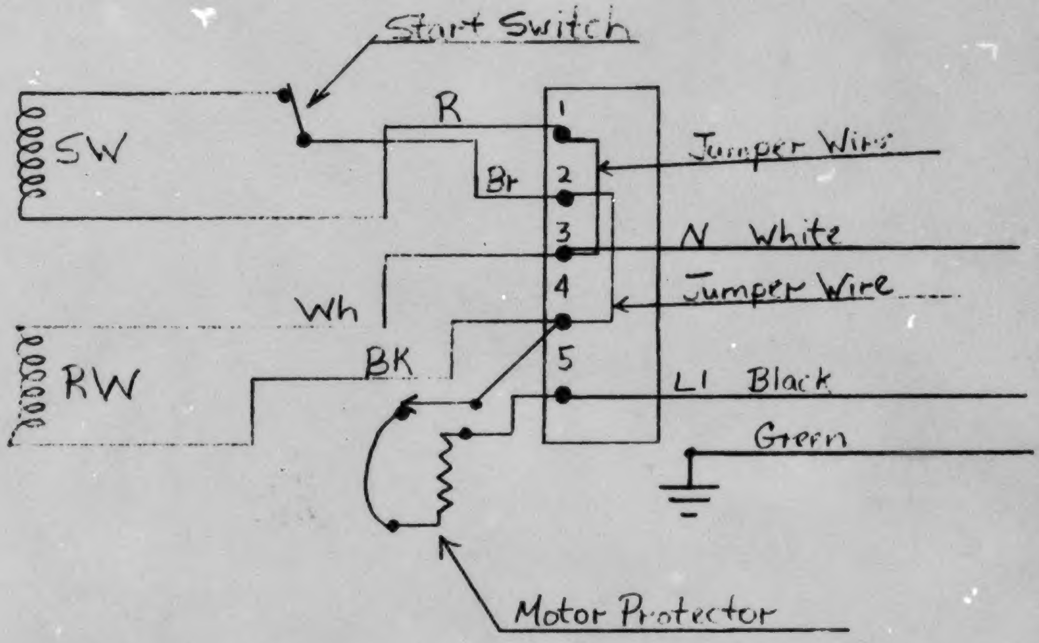
   C. Connect N lead to terminal 3

   D. Move the Br lead to terminal 2

   E. Move the R lead to terminal 1

   (NOTE: Rotation can also be accomplished by rotating leads Wh and Bk between terminals 3 and 4.)

   F. Connect the green lead to motor frame.



G. Place voltmeter at 250 VAC or higher range

H. Clip voltmeter leads to motor terminals 3 and 4

I. Place ammeter at highest range

J. Clamp ammeter around the black L1 lead

K. Have instructor inspect wiring

L. Turn on electrical power and start motor

M. Adjust test meters for most accurate reading

N. Record the following data:

   1. Voltage reading_______________

   2. Current reading_______________

   3. Direction of rotation_______________

   (NOTE: Determine rotation facing shaft end of motor.)

O. Have instructor inspect project

P. Clean up and put away motor and tools

SPLIT-PHASE MOTORS
UNIT II

JOB SHEET #3--DISASSEMBLE, INSPECT, CLEAN, AND REASSEMBLE A SPLIT-PHASE MOTOR

I. Tools and materials

A. Split-phase motor

B. Screwdriver

C. Open end wrench

D. Center punch

E. Ball peen hammer

F. Soft face hammer

G. Small socket wrench set

H. Motor cleaning fluid

I. Clean shop towel

J. Compressed air

K. Safety glasses

L. Polishing cloth

II. Procedure

A. Check to be sure electrical power is disconnected

B. Clean off outer surface of motor

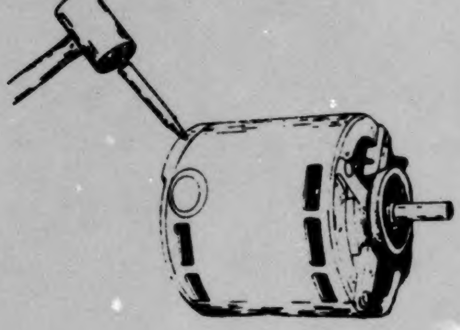
C. Disconnect wires at motor

(NOTE: Be sure to label or draw a diagram of wire positions on motor terminals.)

D. Mark end bells (Figure 1)

(NOTE: This is to keep bell ends in their proper places. Using center punch, place one mark on pulley end bell and two marks on opposite end bell; mark housing in the same way.)

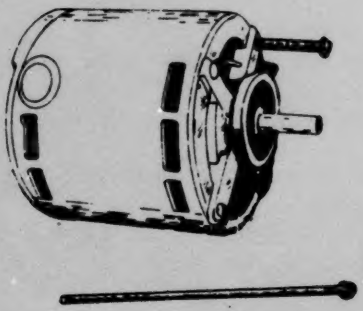
FIGURE 1



E. Remove bolts holding end bells (Figure 2)

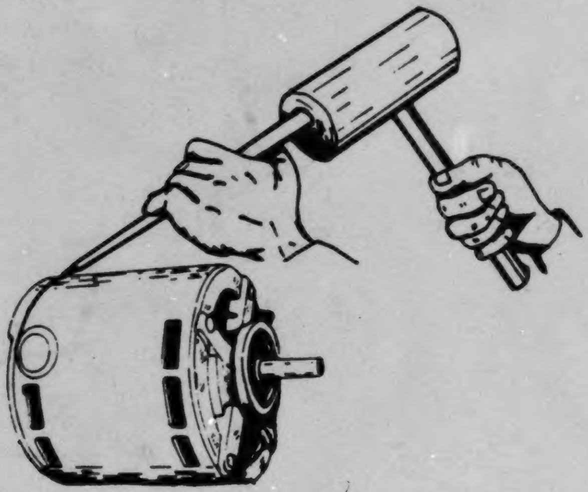
(NOTE: Prior to removing end bells polish shaft ends for easy removal.)

FIGURE 2



F. Use soft-faced hammer and drift punch to tap end bells loose (Figure 3)

FIGURE 3



G. Remove end bell that does not contain starting switch

(NOTE: Observe position and number of shims as you remove the rotor.)

H. Remove rotor

I. Remove end bell containing starting switch

(CAUTION: Do not attempt to remove stator.)

J. Put on safety glasses

K. Clean motor with compressed air

L. Clean outside of motor with special cleaning fluid

M. Make sure wicking is in place and oiled

N. Replace end bell containing switch

O. Insert rotor making sure shims are in place

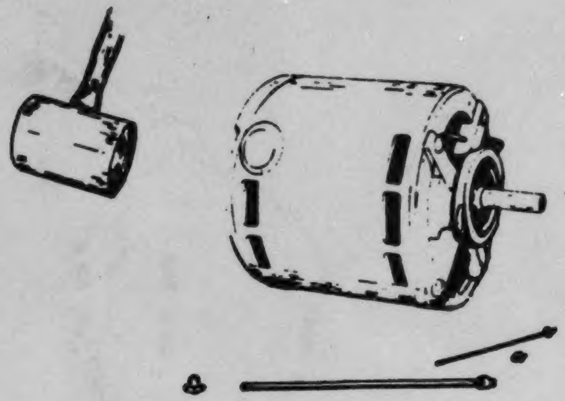
(NOTE: A drop of oil should be placed on bearing part of the shaft.)

P. Visually inspect rotor and stator alignment

Q. Check position of end bells with center punch marks

R. Use soft-faced hammer to tap end bells in place (Figure 4)

FIGURE 4



S. Insert end bell bolts and tighten

T. Turn shaft by hand

(NOTE: If it is tight, end bells may not be in proper alignment, or the wicking may be between bearing and shaft.)

U. Have instructor inspect

V. Connect temporary leads and test motor

W. Clean up and put away tools

S-63-C

SPLIT-PHASE MOTORS
UNIT II

NAME____________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Twisting force created by a motor as it starts and runs

_____b. Winding of motor which has current flowing through it during normal operation of motor

_____c. Motor with two stator windings; while both windings are in use for starting, the starting winding is disconnected by centrifugal switch after motor attains approximately 75 to 80% of its speed, and motor then operates on run winding only

_____d. Winding in the electric motor that is used only briefly while the motor is starting

1. Split-phase motor

2. Start winding

3. Run winding

4. Torque

2. State the common horsepower range of split-phase motors.

3. List two applications of split-phase motors.

a.

b.

4. List the two windings of a split-phase motor.

a.

b.

5. List the characteristics of the windings in a split-phase motor.

a. Start winding

1)

2)

3)

4)

b. Run winding

1)

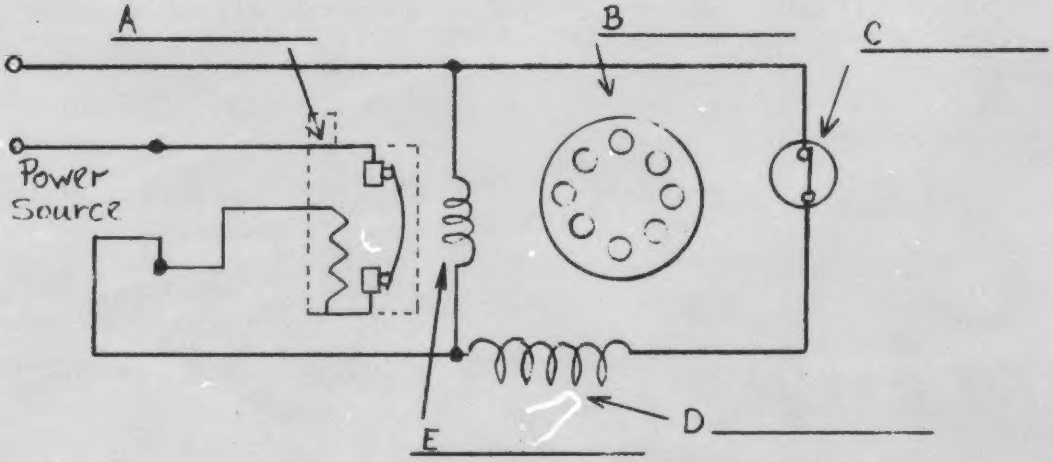
2)

3)

4)

6. Discuss the purpose of the starting mechanism.

7. Identify the components of a split-phase motor.



8. Match start and run windings on the right to the motor lead codes by NEMA.

_____a. T1

_____b. T2

_____c. T3

_____d. T4

1. Start winding
2. Run winding

9. Match the code numbers on the right to the code colors of motor leads.

_____a. Yellow

_____b. Red

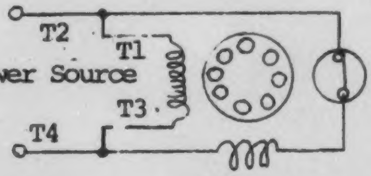
_____c. Black

_____d. Blue

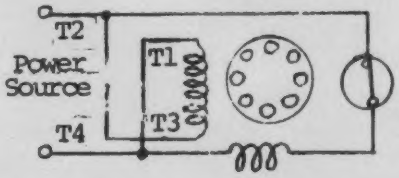
1. T3
2. T1
3. T2
4. T4

10. Identify the directions of rotation.

a. ______________________



b. ______________________



11. Demonstrate the ability to:

a. Wire a split-phase motor to a 115 VAC power supply

b. Reverse rotation of a split-phase motor

c. Disassemble, inspect, clean, and reassemble a split-phase motor

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

SPLIT-PHASE MOTORS
UNIT II

ANSWERS TO TEST

1. a. 4
   b. 3
   c. 1
   d. 2
2. 1/20 to 3/4
3. Any two of the following:
   a. Fans
   b. Pumps
   c. Blowers
4. a. Start
   b. Run
5. a. Start winding
      1) High resistance
      2) Small wire
      3) More turns
      4) Wound on top of run winding in pole slots
   b. Run winding
      1) Low resistance
      2) Heavier wire
      3) Fewer turns
      4) Wound in bottom of pole slots

6. Discussion should include--Removes starting winding when motor reaches approximately 75 to 85% of its synchronous speed.

7. a. Overload (inherent motor protection)
   b. Rotor
   c. Centrifugal starting mechanism or relay
   d. Starting winding
   e. Run winding

8. a. 2
   b. 1
   c. 2
   d. 1

9. a. 1
   b. 2
   c. 4
   d. 3

10. a. Counterclockwise
    b. Clockwise

11. Performance skills evaluated to the satisfaction of the instructor

CAPACITOR MOTORS
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to define terms associated with capacitor motors, list characteristics of capacitor motors and identify the wiring diagrams of different capacitor motors. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Define terms associated with capacitor motors
2. List three characteristics of capacitor motors
3. List two characteristics of C.S.I.R. (Capacitor Start-Induction Run) motors.
4. List two characteristics of P.S.C. (Permanent Split Capacitor) motors.
5. Identify the wiring diagrams of C.S.I.R. and P.S.C. motors.
6. Demonstrate the ability to:
    a. Remove, test, and replace a run capacitor on a P.S.C. pump motor

CAPACITOR MOTORS
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined in the job sheet.

   G. Show students actual capacitor motors.

   H. Disassemble a capacitor motor and place on a display board.

   I. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheet.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--C.S.I.R. Motor Wiring

      2. TM 2--P.S.C. Motor Wiring

D. Job sheets

   1. Job Sheet #1--Remove, test, and replace a run capacitor on a P.S.C. pump motor

E. Test

F. Answers to test

II. References:

A. Schweitzer, Gerald. Basics of Fractional Horsepower Motors and Repair. Rochelle Park, New Jersey: Hayden Book Co., Inc., 1960.

B. Grim, John H. Refrigeration System Components. Sidney, Ohio: Copeland Refrigeration Corp., 1967.

C. Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. Modern Refrigeration and Air Conditioning. Homewood, Illinois: Goodheart-Willcox Co., 1975

CAPACITOR MOTORS
UNIT III

INFORMATION SHEET

I. Terms and definitions

- A. Dual-voltage motors--Motors which are designed to operate on more than one voltage
- B. Capacitor motors--Motors which use a start capacitor and/or a run capacitor in the electrical circuit

II. Characteristics of capacitor motors

- A. Essentially the same design as a split-phase motor

  (CAUTION: Do not attempt to increase the torque of a split-phase motor by inserting a start capacitor in series with the start winding. The windings of split-phase motors and capacitor motors are designed differently and the insertion of a start capacitor in a split-phase motor would cause permanent damage.)

- B. Start capacitor is in series with start winding
- C. Higher starting torque
- D. More efficient, less amperage draw
- E. Run capacitor is in series with the start winding

III. C.S.I.R. (Capacitor Start-Induction Run) motors (Transparency 1)

- A. Designed for heavier loads than split-phase motors
- B. A switch must be provided to remove start capacitor from circuit after starting
- C. Available in single or dual voltage

IV. P.S.C. (Permanent Split Capacitor) motors (Transparency 2)

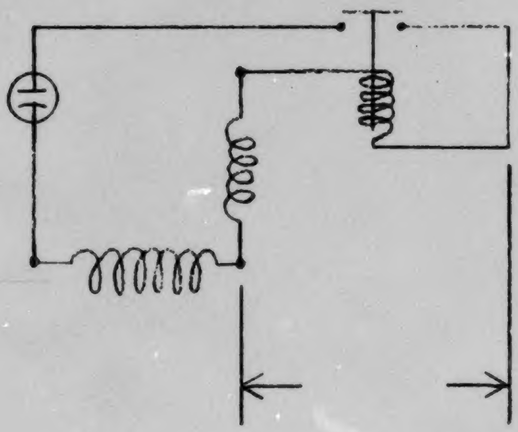
- A. No centrifugal switch
- B. Low starting torque

C. No motor starting relay

D. Direction of rotation may be reversed

(NOTE: This depends on the internal wiring arrangement)

V. Wiring diagrams of C.S.I.R. and P.S.C. motors (Transparencies 1 and 2)



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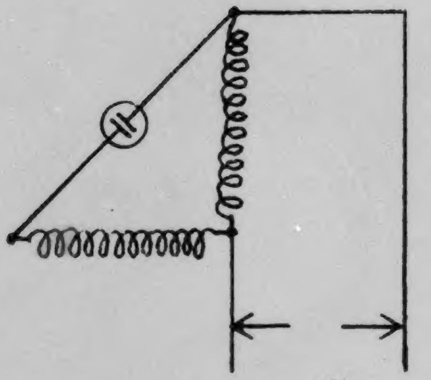

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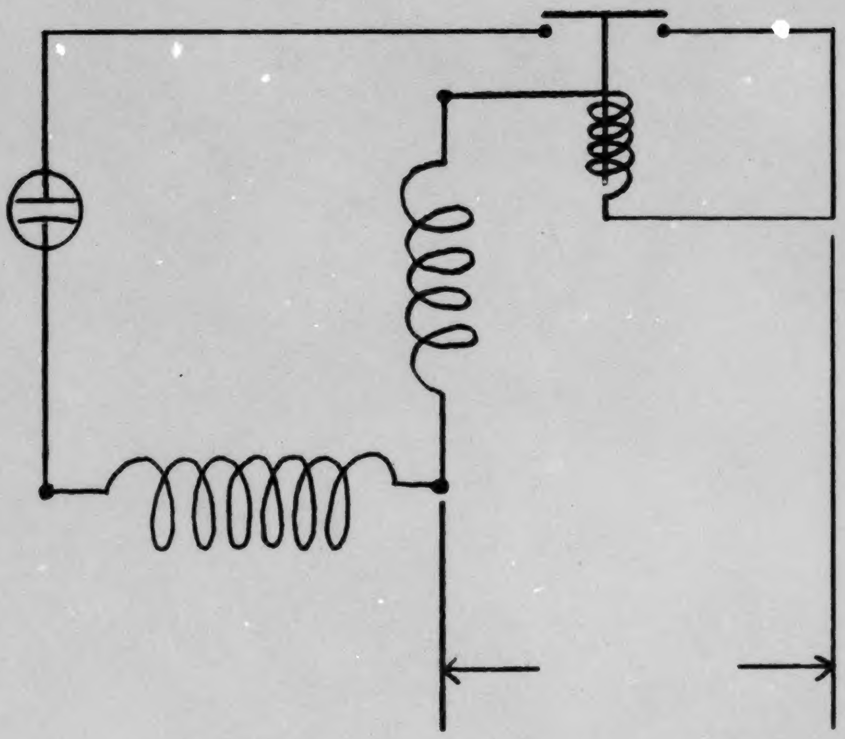
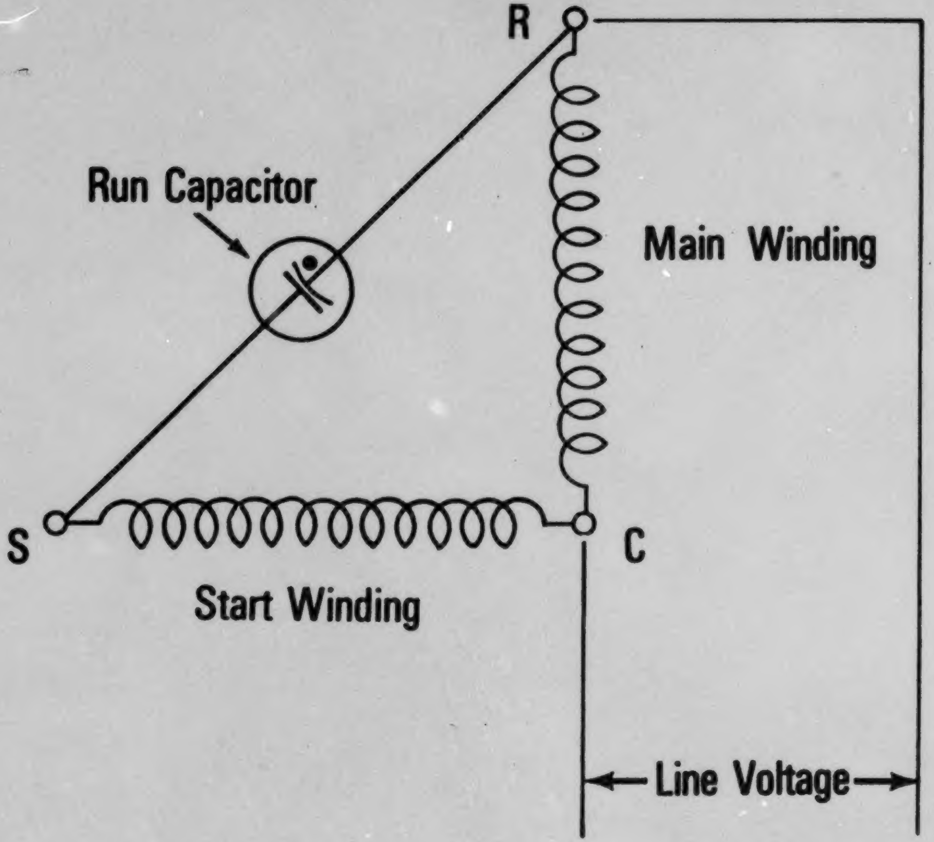
C.S.I.R. Motor Wiring



P.S.C. Motor Wiring



CAPACITOR MOTORS
UNIT III

JOB SHEET #1--REMOVE, TEST, AND REPLACE A RUN CAPACITOR ON A P.S.C. PUMP MOTOR

I. Tools and materials

   A. P.S.C. pump motor

   B. Ohmmeter

   C. Tool box

II. Procedures

   A. Remove run capacitor from pump motor

   B. Set ohmmeter on R x 10,000 scale

   C. Adjust ohmmeter to "0"

   D. Touch the meter leads to the capacitor terminal

   E. Observe needle movement as follows:

      1. Needle moves to zero and stays--shorted capacitor

      2. Needle moves to zero and moves back to left--indicates a good capacitor

      3. Needle does not move to right at all--open capacitor

      (NOTE: Check all capacitors on more than one scale before condemning as open or shorted.)

   F. Check the capacitor for grounded case by touching one ohmmeter lead to either capacitor terminal and the capacitor case

      1. If the needle moves to zero and stays--the capacitor is shorted to ground

      2. If the meter needle does not move--the capacitor is not shorted to ground

   G. Have the instructor evaluate your procedures

H. Return the ohmmeter scale to 250 VAC

I. Replace the capacitor on the pump motor

J. Clean up area and return all tools and materials to their assigned areas

CAPACITOR MOTORS
UNIT III

NAME ______________________

TEST

1. Define the terms associated with capacitor motors.

   a. Capacitor motors-- ______________________

   ____

2. List three characteristics of capacitor motors.

   a. ______________________

   b. ______________________

   c. ______________________

3. List two characteristics of C.S.I.R.-(Capacitor Start-Induction Run) motors.

   a. ______________________

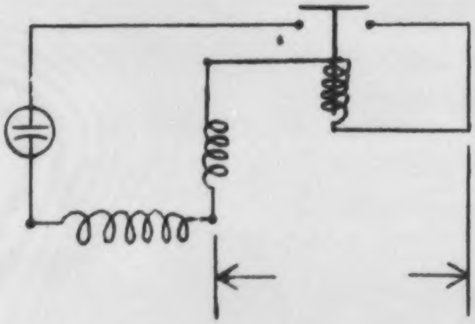
   b. ______________________

4. List two characteristics of a P.S.C. (Permanent Split Capacitor) Motor.

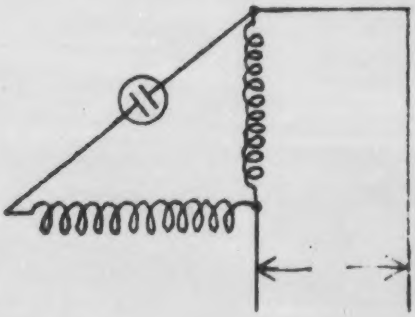
   a. ______________________

   b. ______________________

5. Identify the wiring diagrams of C.S.I.R. and P.S.C. motors



A ______________________



B ______________________

6. Demonstrate the ability to remove, test, and replace a run capacitor

(NOTE: If this activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

CAPACITOR MOTORS
UNIT III

ANSWERS TO TEST

1. a. Capacitor motors--Motors which use a start capacitor and/or a run capacitor in the electrical circuit

2. Any three of the following:

   a. Essentially the same design as a split-phase motor

   b. Start capacitor is in series with start winding

   c. Higher starting torque

   d. More efficient, less amperage draw

   e. Run capacitor is in series with the start winding

3. Any two of the following:

   a. Designed for heavier loads than split-phase motors

   b. A switch must be provided to remove start capacitor from circuit after starting

   c. Available in single or dual voltage

4. Any two of the following:

   a. No centrifugal switch

   b. Low starting torque

   c. No motor starting relay

   d. Direction of rotation may be reversed

5. a. C.S.I.R.

   b. P.S.C.

6. Performance skills evaluated to the satisfaction of the instructor

BASIC HAND TOOLS
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify the basic hand tools used to assemble, install, maintain, and service-residential solar-hot water systems. The student should also be able to demonstrate the proper use and care of these tools. This knowledge will be evidenced by correctly performing the procedures outlined on the assignment and job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with basic hand tools to the correct definitions or descriptions.
2. Identify the basic hand tools.
3. Select the specific tools from similar groups.
4. Match terms associated with proper care of hand tools.
5. List four procedures for reading a rule.
6. List four guidelines for the use and care of rules and steel tapes.
7. Match in proper order the steps involved in cutting and threading iron pipe.
8. Demonstrate the ability to:
   a. Measure lines to the nearest quarter, eighth, and sixteenth of an inch.
   b. Read a rule/tape measure.
   c. Set up and use a hacksaw.

BASIC HAND TOOLS
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet.
- B. Provide student with information, assignment, and job sheets.
- C. Make transparencies.
- D. Discuss unit and specific objectives.
- E. Discuss information and assignment sheets.
- F. Demonstrate and discuss the procedures outlined in the job sheets.
- G. Conduct shop tour of tool crib/tool storage areas.
- H. Give test.

II. Student:

- A. Read objective sheet.
- B. Study information sheet.
- C. Complete assignment and job sheets.
- D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Transparency masters
  1. TM 1--Screwdrivers
  2. TM 2--Wrenches
  3. TM 3--Pliers

2

4. TM 4--Hammers
5. TM 5--Punches, Chisels, and Bars
6. TM 6--Files
7. TM 7--Socket Sets
8. TM 8--Tubing Tools
9. TM 9--Tools for Cutting and Threading Iron Pipe
10. TM 10--Accessory Hand Tools
11. TM 11--Threading Tools
12. TM 12--Graduations on a Rule
13. TM 13--Reading the Eighths Rule
14. TM 14--Reading the Sixteenths Rule

D. Assignment Sheets

1. Assignment Sheet #1--Measure Lines to the Nearest Quarter, Eighth and Sixteenth of an Inch
2. Assignment Sheet #2--Read a Rule/Tape Measure

E. Answers to assignment sheets

F. Job Sheet

1. Job Sheet #1--Set up and Use a Hacksaw

G. Test

H. Answers to test

II. References:

A. Blankenbaker, E. Keith Modern Plumbing. South Holland, Ill.: Goodheart-Willcox Company, 1978.

B. Bureau of Naval Personnel. Tools and Their Uses. Washington, D.C.: United States Government Printing Office, 1971.

BASIC HAND TOOLS
UNIT I

INFORMATION SHEET

I. Terms and definitions

   A. Hand tool--Tool which is hand held and is not electrical or specialized

   (NOTE: The majority of work done in residential solar is done with hand tools.)

   B. Specialized tool--Tool designed for a particular use

   C. Technician's tool box--Personalized tool kit containing the basic hand tools

   D. Pipe cutters--Tools used for cutting pipe

   E. Pipe wrenches--Tools used to turn threaded pipe and fittings, made in a variety of sizes and shapes

   F. Threading--Method of developing spiral cuts on pipe in order to facilitate joining

   G. Male/female--Designates joints of pipe in reference to the fitting; female receives the male pipe

   H. Pipe thread--A special thread designed for piping systems; does not fit objects with machine threads

   I. Safety--The condition of being safe from undergoing or causing hurt, injury, or loss

   (NOTE: Technicians usually purchase their own hand tools, therefore, one must develop a special responsibility towards tool care.)

II. Basic hand tools

   A. Screwdrivers (Transparency 1)

      1. Standard slot

      2. Phillips

      3. Clutch head

      4. Stubby

    5. Offset

B. Wrenches (Transparency 2)

    1. Open end
    2. Box end
    3. Combination
    4. Adjustable open end
    5. Pipe
    6. Flare nut

C. Pliers (Transparency 3)

    1. Slip joint
    2. Slip groove
    3. Long nose
    4. Diagonal cutters
    5. Plier wrench

D. Hammers (Transparency 4)

    1. Ball peen
    2. Soft face
    3. Long handle sledge
    4. Straight claw

E. Punches, chisels, and bars (Transparency 5)

    1. Pin punch
    2. Center punch
    3. Flat chisel (cold chisel)
    4. Pry bar
    5. Scratch awl
    6. Wood chisel

F. Files (Transparency 6)
  1. Flat
  2. Half round
  3. Round
  4. Point
  5. Triangular
  6. Handle

G. Sockets sets (Transparency 7)
  1. Ratchet handle
  2. Socket
  3. Deep socket
  4. Hinge handle (break-arm)
  5. Extension
  6. Speed handle
  7. Universal joint

H. Tubing tools (Transparency 8)
  1. Flaring tool
  2. Tubing reamer
  3. Flaring block
  4. Cutter
  5. Swage punch
  6. Lever type bender
  7. Bending spring
  8. Geared ratchet-type bender

I. Iron pipe tools (Transparency 9)
  1. Pipe vise
  2. Dies and die head

3. Pipe reamer
4. Pipe cutter
5. Die stock

J. Accessory hand tools (Transparency 10)

1. Drop light
2. Hacksaw
3. Safety glasses
4. Nut drivers
5. Level
6. Hex key wrenches
7. Cutting oil

K. Threading tools (Transparency 11)

1. Tap
2. Die
3. Die stock
4. T-handle tap wrench
5. Hand tap wrench

III. Hand tool use

A. Screwdrivers

1. Standard slot--For tightening or loosening bolts and screws with a slot type head
2. Phillips--For tightening or loosening bolts and screws with a phillips type head

   (NOTE: Use proper size to prevent rounding out screw slots.)

3. Clutch head--For tightening or loosening a clutch head bolt or screw

   (NOTE: The blade must fit the screw slot in order to function properly.)

4. Stubby--For working in close places where a longer blade would not fit

5. Offset--For working in extremely close places

B. Wrenches

1. Open end--For tightening or loosening hex head bolts, nuts, or screws

2. Box end--For tightening or loosening hex head bolts, nuts, or screws, but is less likely to slip off

3. Combination--Box and open ends for tightening or loosening hex head bolts, nuts, or screws

   (NOTE: This wrench has both an open end and a box end and it enables you to carry a fewer number of wrenches.)

4. Adjustable open end--For tightening or loosening various sizes of nuts and bolts

5. Pipe--Primarily for tightening or loosening round pipe or other rounded surfaces

   (NOTE: This wrench will adjust to fit various size surfaces and it also has teeth to prevent slipping.)

6. Flare nut--For tightening or loosening a flare nut; it has a box end with a notch cut out so that it can be slipped over the tubing

C. Pliers

1. Slip joint--For holding or turning a part where marring of the surface is not a problem

2. Slip groove--For the same purpose as slip joint pliers, but the jaws will generally open wider and the handles provide more leverage

3. Long nose--For holding or reaching small items

4. Diagonal cutters--For cutting wire

   (NOTE: These should not be used for tin snips.)

5. Plier wrench--For an excessively tight grip; it has a locking lever to prevent slipping

(NOTE: These are commonly referred to as vise-grips.)

D. Hammers

1. Ball peen--For hammering on metal tools such as punches and chisels
2. Soft face--For hammering on or driving materials that a steel face hammer would mar or break

   (NOTE: Soft face hammer faces are made of plastic, rubber, rawhide, copper, lead, or wood.)
3. Sledge--For breaking and pounding; it is heavy, long handled, and has a steel face
4. Claw--Generally for driving or pulling nails

E. Punches, chisels, and bars

1. Pin punch--For driving both straight and tapered pins in or out of hubs and shafts
2. Center punch--For making indentations in metal for starting a drill
3. Flat chisel--For cutting off bolt heads or splitting nuts

   (NOTE: A flat chisel is sometimes referred to as a cold chisel.)
4. Pry bar--Generally for jobs that require prying an object into alignment
5. Scratch awl--Generally for scratching a line on metal, making screw holes in sheet metal, and for aligning screw holes
6. Wood chisel--Used to cut notches and holes in wood structure for pipes

F. Files

1. Flat--For smoothing metal surfaces; it is a double cut file
2. Half round--For filing rounded surfaces on metals

3. Round--Generally for enlarging holes in metal

   (NOTE: Round files taper to a point and are sometimes referred to as "rat-tail" files.)

4. Point--For filing contact points; it is a small, thin file

5. Triangular--Generally for cleaning up damaged threads

   (NOTE: Slim taper files are sometimes called saw files.)

6. File handle--Wooden handle placed on the end of the file to prevent it from gouging one's hand

G. Socket sets

(NOTE: Socket sets are made in 1/4" and 1/2" for light and heavy jobs.)

1. Ratchet--Permits tightening or loosening with very little swinging room; it is a drive handle that sockets fit onto

2. Socket--For tightening or loosening a hex head bolt or nut; used in conjunction with a drive handle

3. Deep socket--Socket with an extended wall for reaching recessed bolts and nuts or nuts that have the bolt extending through them so far that the standard socket will not fit over them

4. Hinge handle--Drive handle that is used with sockets when more force is needed to break loose or tighten a nut or bolt

   (NOTE: These handles are sometimes called break-overs.

5. Extension--Rod that fits between the socket and the drive handle to extend the socket into hard to reach places

6. Speed handle--Drive handle used with a socket to tighten or loosen bolts and nuts quickly that are easy to reach

7. Universal joint--Fits between the drive handle and the socket and bends in any direction enabling the socket to get to hard to reach nuts or bolts

H. Tubing tools

1. Flaring tool--For forcing a 45° cone into the end of a piece of tubing being held by a flaring block which creates a flare on the tubing

2. Tubing reamer--For removing the burr from the inside of tubing after it has been cut

   (NOTE: This is usually attached to the tubing cutter.)

3. Flare block--For holding the tubing while it is being flared or swaged

4. Tubing cutter--For cutting the tubing by tightening it onto the tubing and rotating it at the same time

   (NOTE: These come in large, medium, and small sizes.)

5. Swage punch--Driven into the end of a tube to enlarge it so that another tube of the same size may be placed in it and soldered

   (NOTE: Swage punches are made in various sizes: 1/2", 3/4", 1".)

6. Lever-type bender--Tubing is held securely against the bender and the arm is slid over the tubing forcing the tubing into the rounded end of the bender

7. Bending spring--Coil spring which is placed on the outside of tubing to keep it from collapsing while bending

I. Accessory hand tools

1. Drop light--For light in dark work areas; it has a protective reflective shield and an electrical outlet in the handle

   (NOTE: These lights usually have 25 ft. or longer cord and should not be used as power cords for high amperage loads.

2. Handsaw--Small saws used for notching access holes and also for cutting plastic pipe

3. Oil can--Should have a flexible spout for reaching difficult places and a cap to prevent spillage

4. Hacksaw--For cutting metals

   (CAUTION: A hacksaw is not recommended for cutting pipe and tubing; use tubing cutters and pipe cutters.)

5. Safety glasses--Eye protection that should be worn on all jobs

6. Level--For checking the levelness of fixtures and the pitch of pipe

   (NOTE: Two kinds of levels are the small bubble level and the torpedo level.)

7. Hex key wrenches--For loosening or tightening socket type set screws in English and metric sizes

J. Threading tools

1. Taps--For cutting threads inside of hole

   (NOTE: These are available in all types and sizes of threads.)

2. Dies--For cutting external threads on pipe

   (NOTE: These are available in all types and sizes of threads.)

3. Handles--For holding taps and dies during the threading process

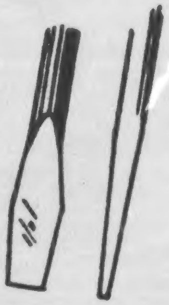
   (NOTE: These include T-handles and hand tap wrenches that hold taps and die stocks for holding dies.)

IV. Hand tool care

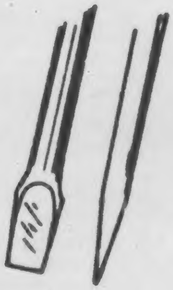
A. Screwdrivers

1. Grind flat tip square

Ground Right



Ground Wrong

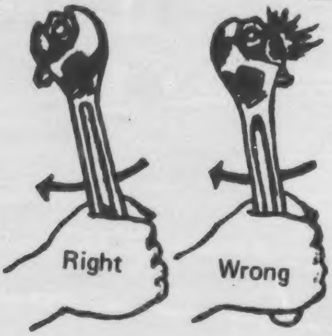


2. Discard worn phillips tips

3. Do not hammer on screwdrivers

B. Wrenches

1. Turn adjustables in proper direction



2. Do not hammer on wrenches

3. Do not hammer with wrenches

C. Pliers

1. Do not use in place of wrench

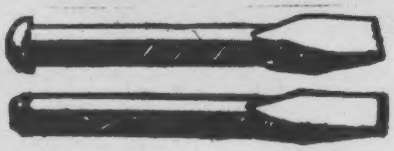
2. Have handles insulated when working on electrical circuits

D. Hammers

1. Keep handles tight
2. Use the proper type hammer for the job

E. Punches, chisels, and bars

1. Keep cutting edges and points sharp



Before and After Dressing

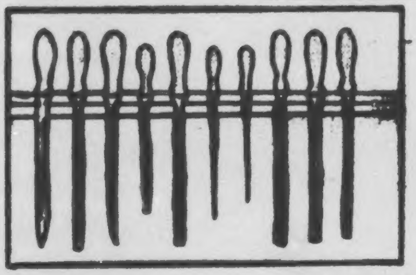
(NOTE: Do not overheat chisel points.)

2. Keep head ground to prevent mushrooming

F. Files

1. Keep files on a wall rack

(NOTE: They will become dull if stacked in a drawer.)



2. Do not hammer or pry with a file

(NOTE: They are very brittle and will break.)

G. Socket sets

1. Do not use an extension pipe or cheater bar on the handle of a ratchet

   (NOTE: Too much force will strip the gears in the ratcheting mechanism.)

2. Do not use a handle and extension pipe with thin wall sockets

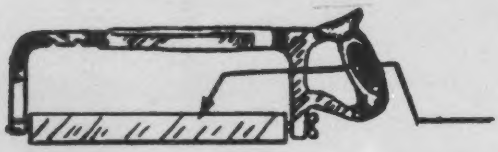
   (NOTE: Thin wall sockets will break.)

H. Tubing tools

1. Oil threads on flaring tool
2. Replace cutting wheel on cutter when dull

I. Accessory hand tools

1. Drop light cords should not be run over with appliance dollys or other carts
2. Protect the blade on a hacksaw with a piece of cardboard to prevent dulling of the teeth



   (NOTE: The teeth of a hacksaw blade should always be pointing forward.)

3. Safety glasses should be kept in a case when not in use

4. Nut drivers should only be used on hand tight nuts, bolts, and screws; do not use pliers for increased leverage

5. Levels should never be dropped

6. Do not apply too much force to hex key wrenches

   (NOTE: Too much force will break or round out the socket of the set screw.)

J. Threading tools

   1. Use plenty of cutting oil when threading

   2. Do not keep taps and dies loose in a drawer

      (NOTE: This will dull the cutting teeth.)

V. Reading a rule (Transparencies 12, 13, and 14)

   A. All rules read similarly

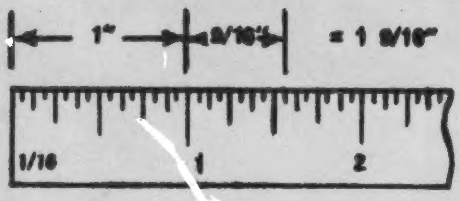
      (NOTE: Some rules are graduated with more divisions per inch than others.)

   B. Procedure for reading

      1. Count the divisions in one inch

2. Determine inches and divisions

   a. Count the graduations after the last full inch



   b. Add fractions to the last full inch

3. Reduce the fraction if possible

4. Determine the feet and add the inches and fraction of an inch to obtain a correct measurement

VI. Guidelines for the use and care of rules and steel tapes

   A. Use the proper length and graduation

   B. Use finest graduation for accuracy

   C. Use a good quality rule

   D. Never bend or distort a steel rule

   E. Use only for intended purpose

   F. Rewind steel tapes slowly

VII. Cutting and threading iron pipe

   A. Secure pipe in vise

   B. Cut the pipe

   (NOTE: Cut end must be square.)

   C. Ream inside of pipe to remove burrs

   D. Lightly file outside cut edge if necessary

   E. Inspect and clean dies before threading

   F. Check cutting edges for sharpness

G. Be sure dies are in the die stock properly

H. Center die on pipe

I. Turn die slowly in a clockwise direction

J. Apply cutting oil while threading

(NOTE: A good grade of sulphur base cutting oil eases cutting and cools die threads.)

K. Determine length of the threaded portion

(NOTE: This can be determined by using Table 1.)

TABLE 1

SPECIFICATIONS FOR THREADING PIPE

Nominal Size of Pipe in Inches	Approx. Length of Threads in Inches	Approx. Number of Threads To Be Cut
1/2	3/4	10
3/4	3/4	10
1	7/8	10
1 1/4	1	11
1 1/2	1	11
2	1	11
2 1/2	1 1/2	12
3	1 1/2	12
4	1 3/4	13

L. Remove die by turning counterclockwise

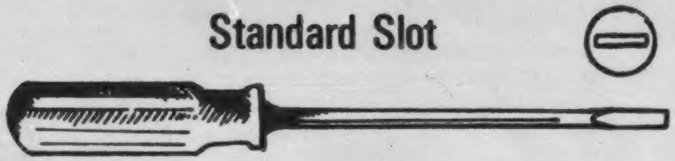
M. Clean chips from threads

N. Clean chips from dies

(CAUTION: Do not remove chips with compressed air.)

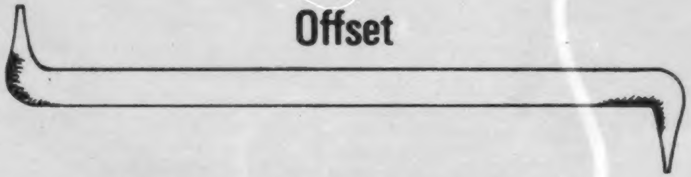
Screwdrivers

Standard Slot

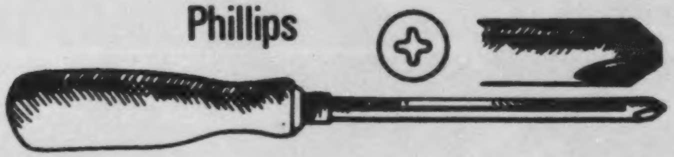


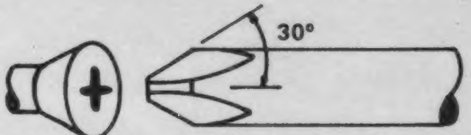
Stubby

Offset



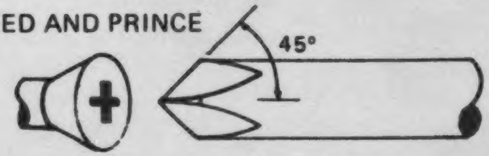
Phillips



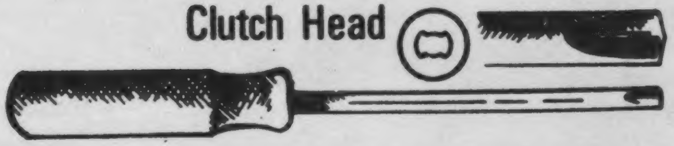


PHILLIPS

REED AND PRINCE

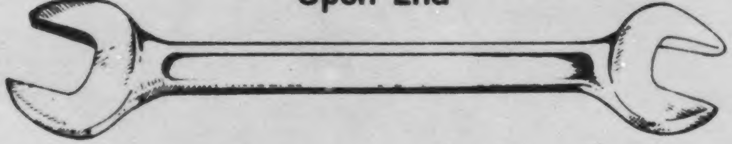


Clutch Head

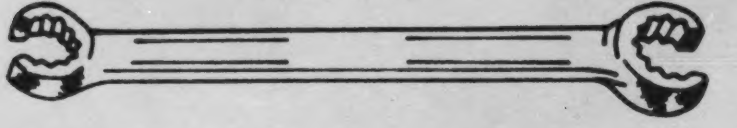


Wrenches

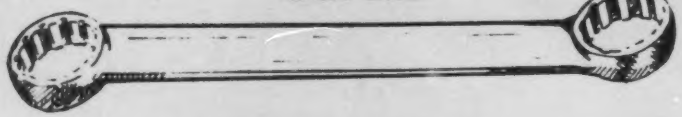
Open End



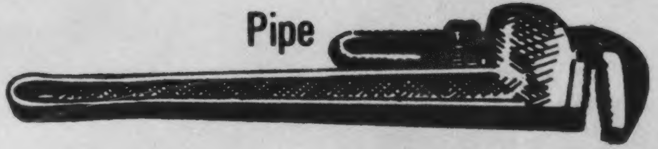
Flare Nut



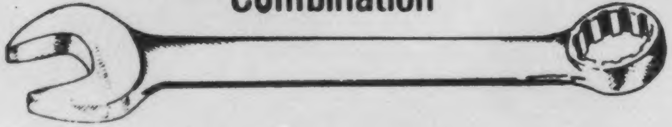
Box End



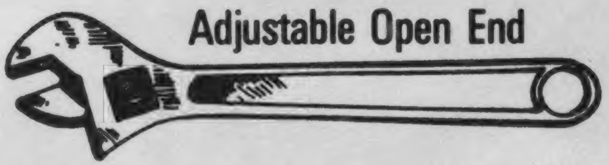
Pipe



Combination

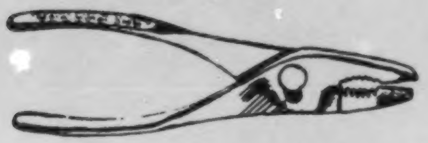


Adjustable Open End

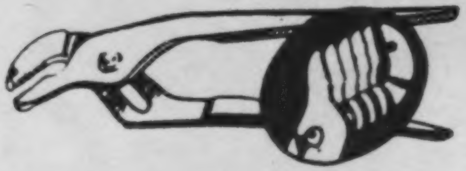


Pliers

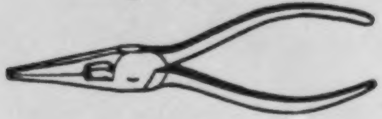
Slip Joint



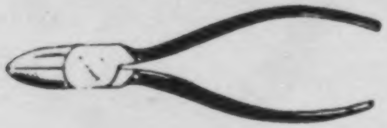
Slip Groove



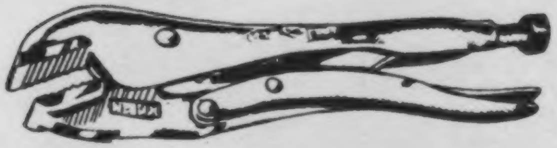
Long Nose



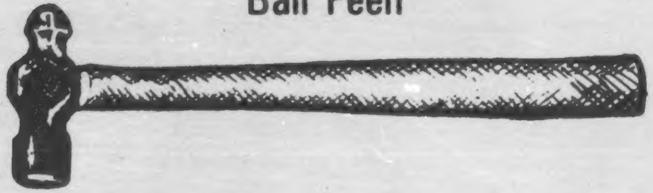
Diagonal Cutters

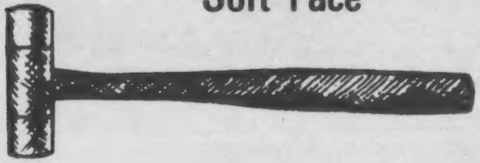


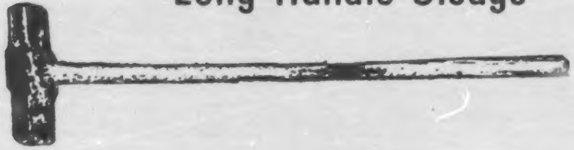
Plier Wrench

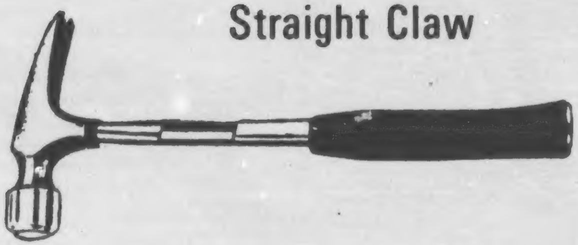


Hammers


Ball Peen

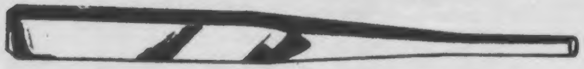

Soft Face


Long Handle Sledge


Straight Claw

Punches, Chisels, and Bars

Pin Punch



Center Punch

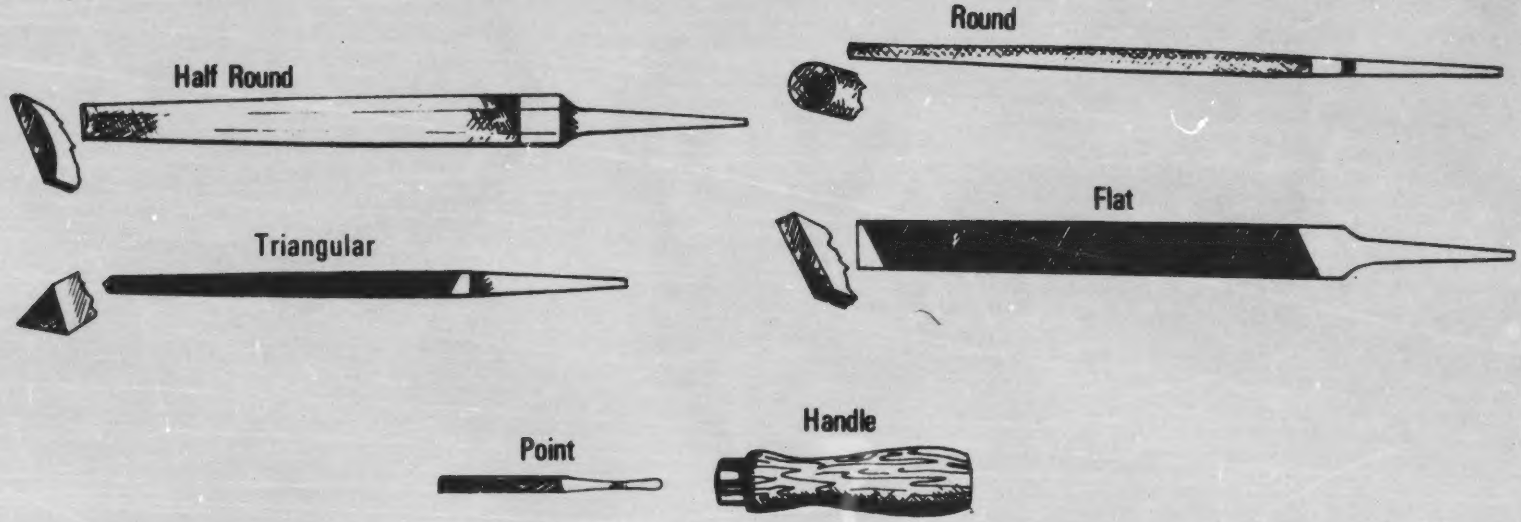
Flat Chisel

Scratch Awl

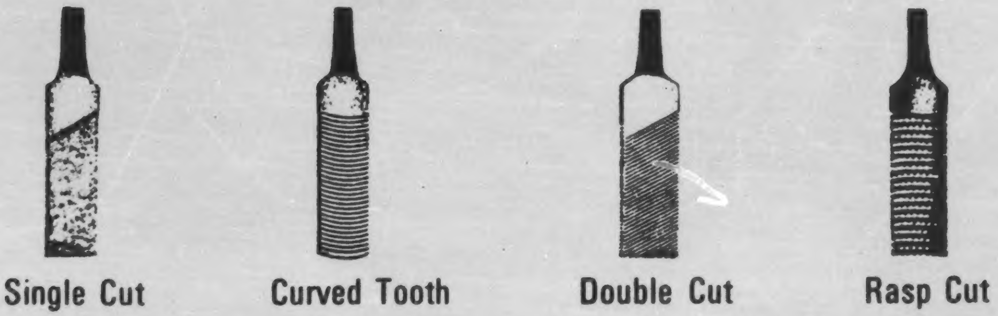
Wood Chisel

Pry Bar

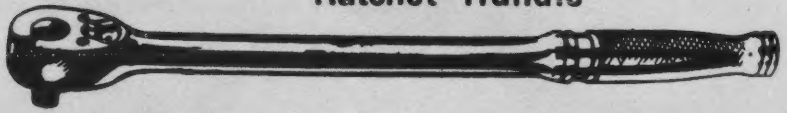
Files

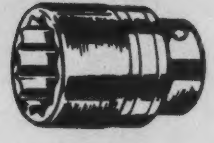


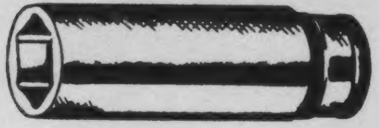
Types of File Teeth

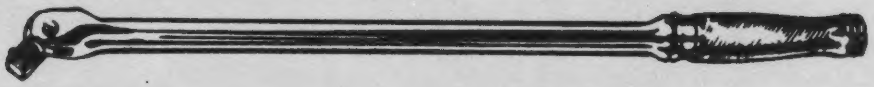


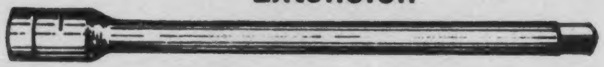
Socket Sets

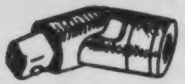

Ratchet Handle

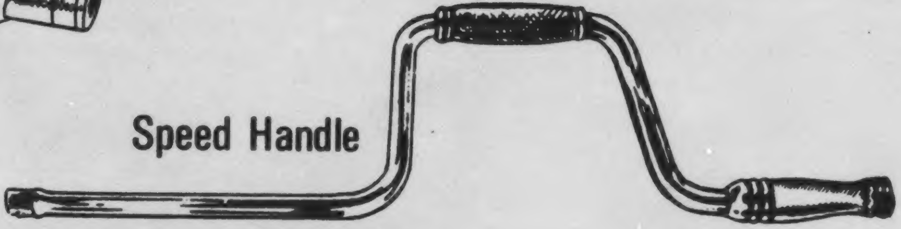

Socket


Deep Socket


Hinge Handle (Break-Arm)

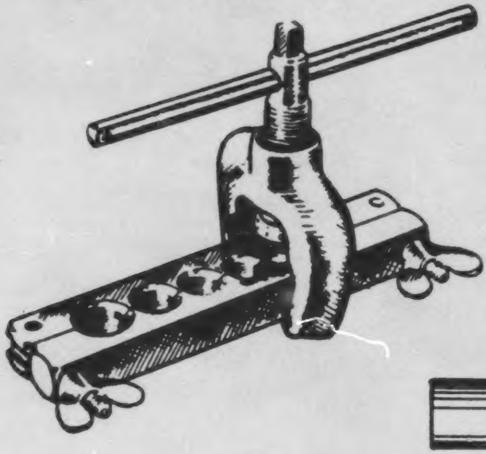

Extension


Universal Joint


Speed Handle

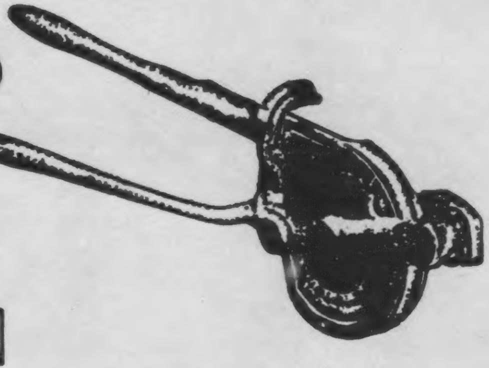
Tubing Tools

Flaring Tool and Block

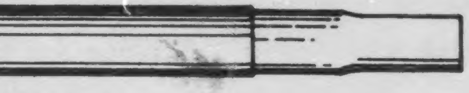


Bending Spring

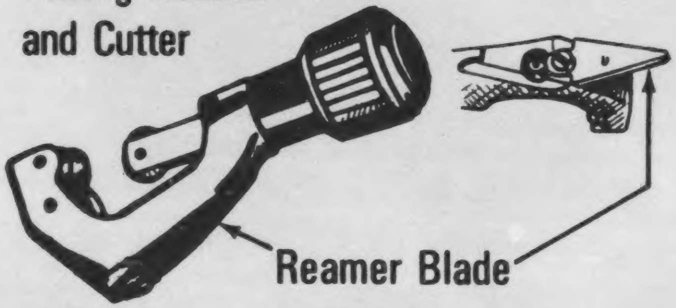
Geared Ratchet-Type Bender



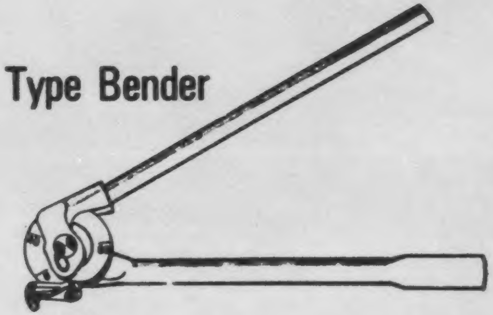
Swage Punch



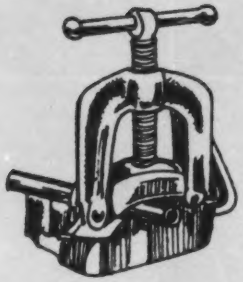
Tubing Reamer and Cutter



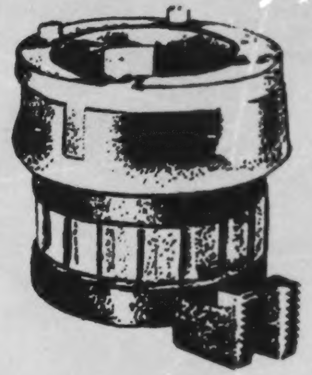
Lever Type Bender



Tools For Cutting and Threading Iron Pipe

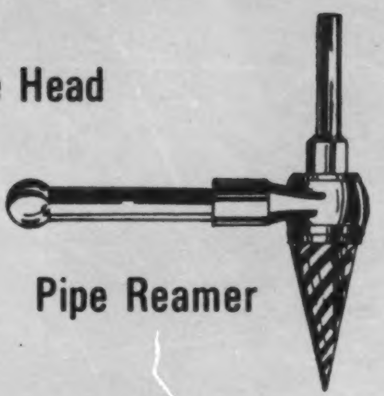


Pipe Vise

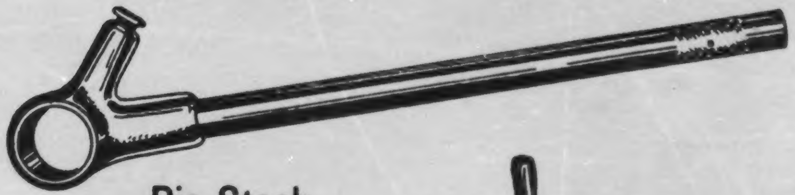


Die Head

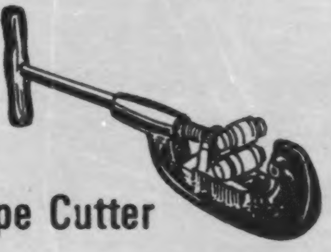
Dies



Pipe Reamer



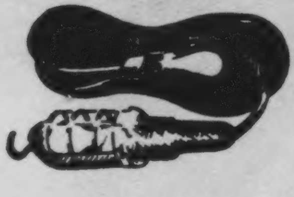
Die Stock



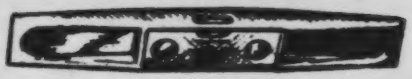
Pipe Cutter

Accessory Hand Tools

Nut Driver

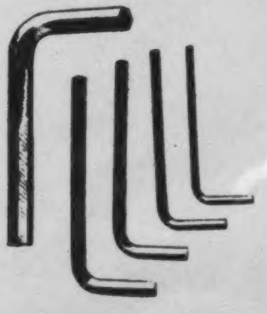

Drop Light

Safety Glasses


Level

Hacksaw

Cutting Oil
or Lubricating

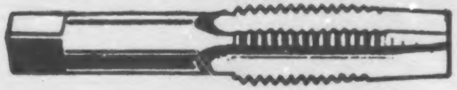

Hex Key Wrenches

TM 10

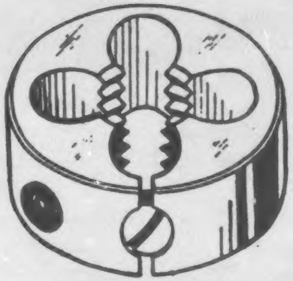
S-39-D

Threading Tools

Tap

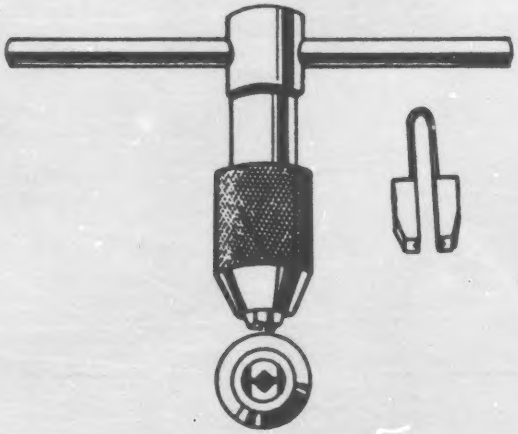


Die

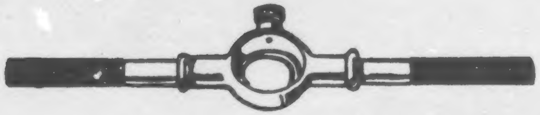


Handles

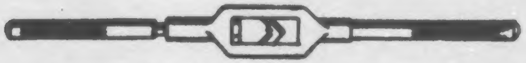
T-Handle Tap Wrench



Die Stock

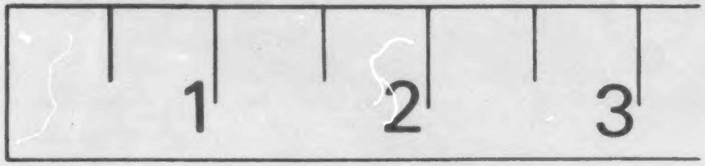


Hand Tap Wrench

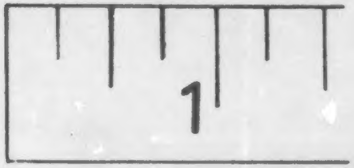


Graduations on a Rule

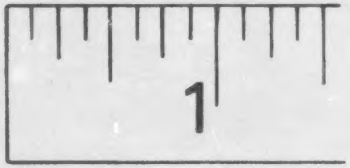
Halves



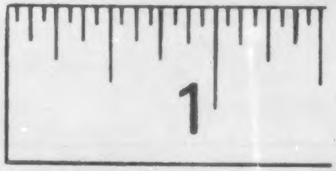
Quarters



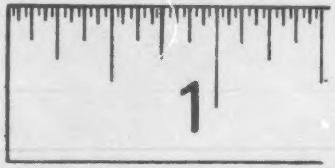
Eighths

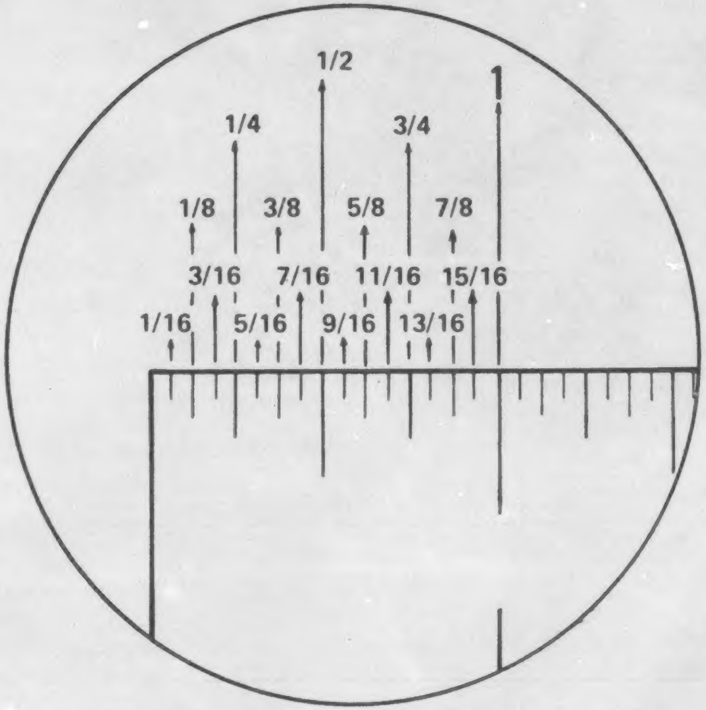


Sixteenths



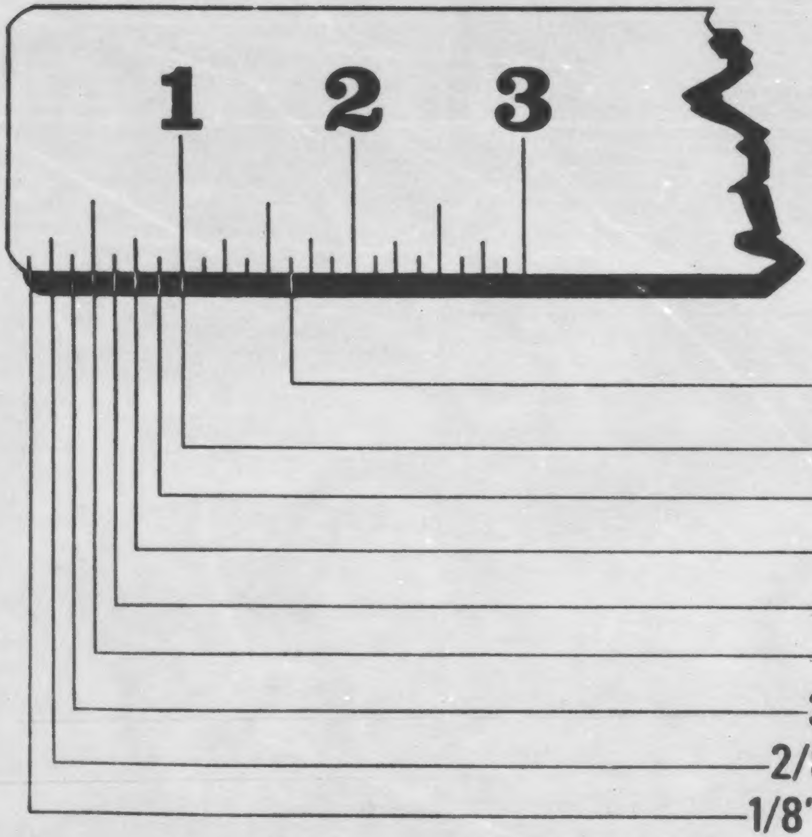
Thirty-Seconds





Graduations Applied to a Rule

Reading the Eighths Rule



13/8" = 1 5/8"

8/8" = 1"

7/8"

6/8" = 3/4"

5/8"

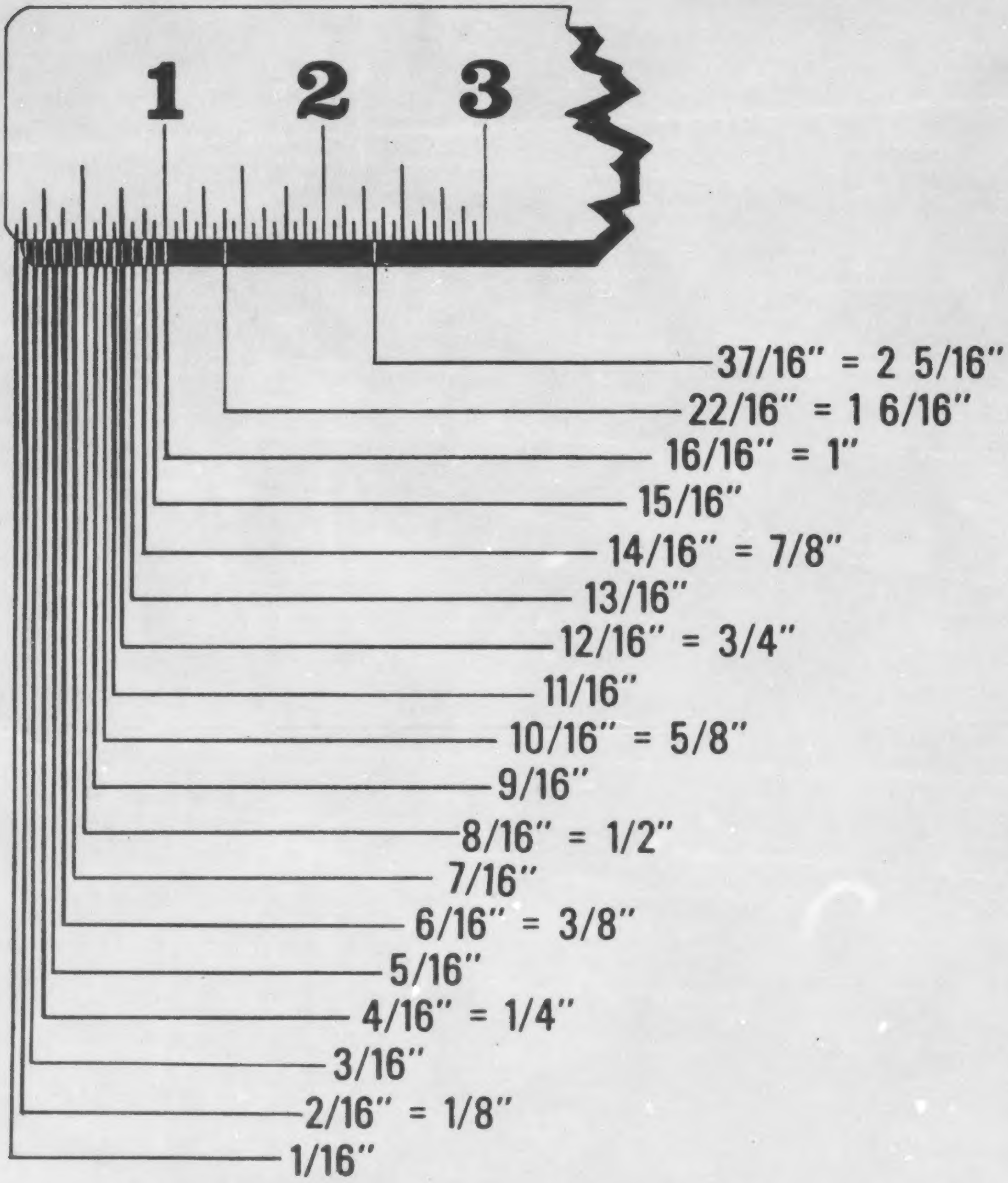
4/8" = 1/2"

3/8"

2/8" = 1/4"

1/8"

Reading the Sixteenths Rule



S-49-D

BASIC HAND TOOLS
UNIT I

ASSIGNMENT SHEET #1--MEASURE LINES TO THE NEAREST QUARTER, EIGHTH AND SIXTEENTH OF AN INCH

1. Measure these lines to the nearest quarter of an inch.

a. ______________________________

b. ____

c. __________

d. ___________________

Answers

a. _______

b. _______

c. _______

d. _______

2. Measure these lines to the nearest eighth of an inch.

a. ____

b. ________________________

c. __________________________________

d. ____

Answers

a. ________

b. ________

c. ________

d. ________

3. Measure these lines to the nearest sixteenth of an inch.

a. _______________________________________

b. __________

c. __________________________

d. ________________________________

Answers

a. __________

b. __________

c. __________

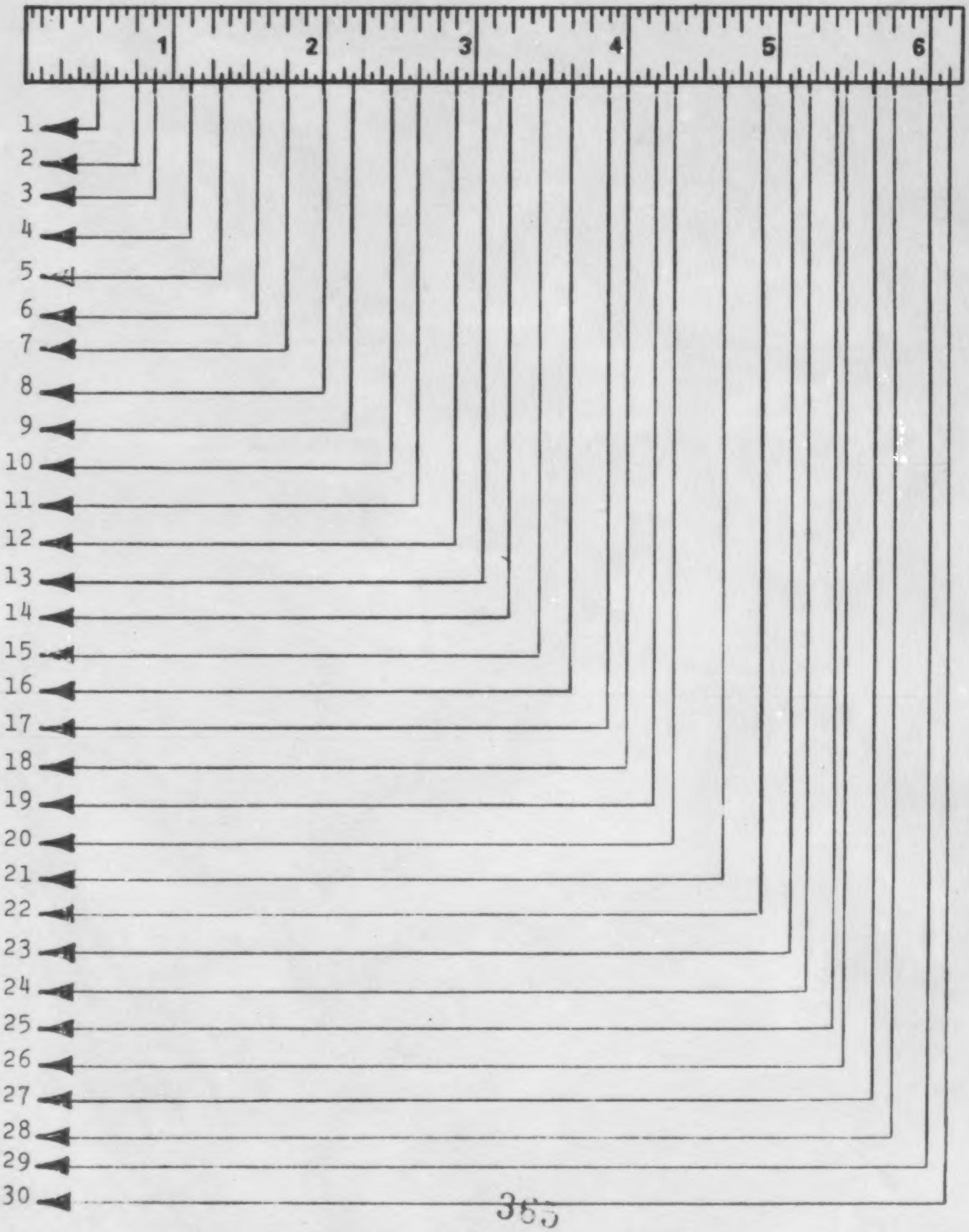
d. __________

BASIC HAND TOOLS
UNIT I

ASSIGNMENT SHEET #2--READ A RULE/TAPE MEASURE

Determine the correct dimension for each arrow. Please answer on the arrow.

Example: Arrow 1 = 1/2"



BASIC HAND TOOLS
UNIT I

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. a. 3 1/4"
   b. 4 1/2"
   c. 1"
   d. 2"
2. a. 4 3/4"
   b. 2 1/2"
   c. 3 5/8"
   d. 4 1/4"
3. a. 4 1/16"
   b. 1 1/16"
   c. 2 5/8"
   d. 3 5/16"

Assignment Sheet #2

2. 3/4"
3. 7/8"
4. 1 1/8"
5. 1 5/16"
6. 1 9/16"
7. 1 3/4"
8. 2"
9. 2 3/16"
10. 2 7/16"
11. 2 5/8"
12. 2 7/8"
13. 3 1/16"
14. 3 1/4"
15. 3 7/16"
16. 3 5/8"
17. 3 7/8"
18. 4"
19. 4 3/16"
20. 4 5/16"
21. 4 5/8"
22. 4 7/8"
23. 5 1/16"
24. 5 3/16"
25. 5 3/8"
26. 5 7/16"
27. 5 5/8"
28. 5 3/4"
29. 6"
30. 6 1/8"

BASIC HAND TOOLS
UNIT I

JOB SHEET #1--SET UP AND USE A HACKSAW

EVALUATION--Given access to tools, equipment and materials, set up and use a hacksaw. Evaluation will include safety precautions used, correct use of tools and equipment, accuracy of cut, and general neatness of the work performed.

I. Tools and equipment

   A. Hacksaw frame

   B. Hacksaw blade

   (NOTE: For cutting pipe a 24 or 32 teeth/inch blade is recommended.)

   C. Pipe

   D. Pipe vise

   E. Safety glasses

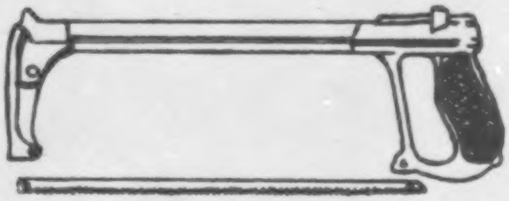
II. Procedure

   A. Put on safety glasses and gather tools and equipment

   B. Insert blade in frame and tighten (Figure 1)

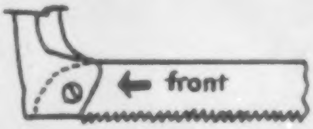
   (NOTE: Hand tighten only; being too tight can cause the blade to shatter.)

FIGURE 1



(NOTE: Be sure teeth angles are pointed toward the front of the saw. See Figure 2.)

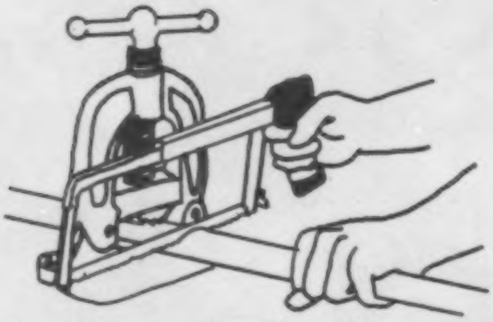
FIGURE 2



C. Secure pipe for cutting (Figure 3)

(NOTE: Short pieces of pipe are easier to cut if secured in a vise.)

FIGURE 3



D. Rest the blade on the pipe at the point to be cut

E. Push forward gently until cut is started

(NOTE: Exert downward pressure only on the forward stroke.)

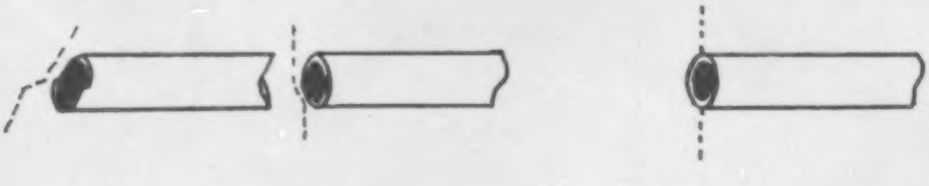
F. Make reciprocal strokes until cut is finished

(NOTE: Excessive speed while cutting can ruin blades. You should not use over thirty full strokes per minute.)

G. Have the instructor check your cut (Figure 4)

(NOTE: Your cut should be straight and relatively smooth.)

FIGURE 4



BASIC HAND TOOLS
UNIT I

NAME________________________

TEST

1. Match the terms on the right to the correct definitions or descriptions.

_____a. Tool which is hand held and is not electrical or specialized

_____b. Tool designed for a particular use

_____c. Personalized tool kit containing the basic hand tools

_____d. Tools used for cutting pipe

_____e. Tools used to turn threaded pipe and fittings, made in a variety of sizes and shapes

_____f. Method of developing spiral cuts on pipe in order to facilitate joining

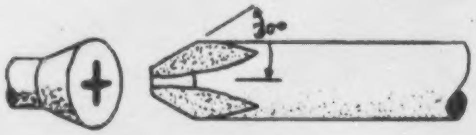
_____g. Designates joints of pipe in reference to the fitting; female receives the male pipe

_____h. A special thread designed for piping systems; does not fit objects with machine threads

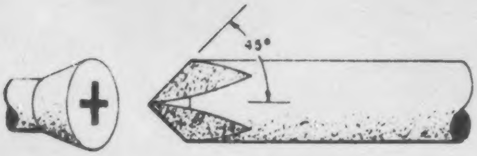
_____i. The condition of being safe from undergoing or causing hurt, injury, or loss

1. Threading
2. Male/female
3. Pipe wrenches
4. Technician's tool box
5. Pipe cutters
6. Specialized tool
7. Hand tool
8. Pipe thread
9. Safety

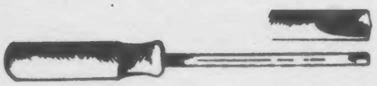
2. Identify the basic hand tools.



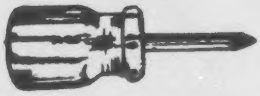
a. ______________________   b. ______________________



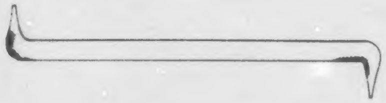
c. ______________________________



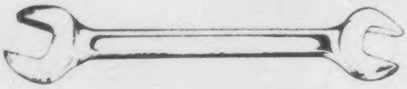
d. ______________________________



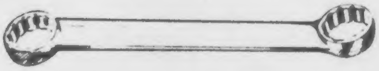
e. ______________________________



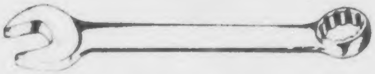
f. ______________________________



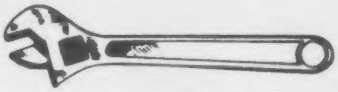
g. ______________________________



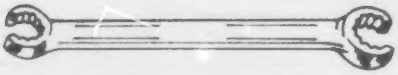
h. ______________________________



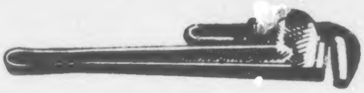
i. ______________________________



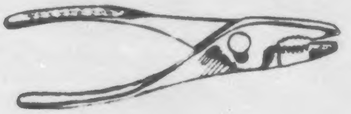
j. ______________________________



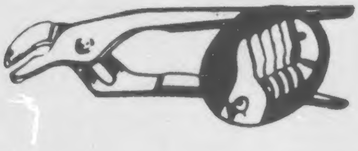
k. ______________________________



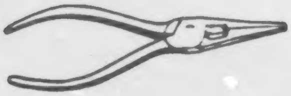
l. ______________________________



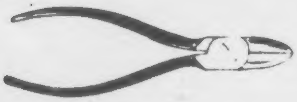
m. ______________________



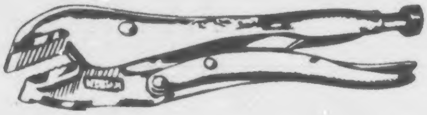
n. ______________________



o. ______________________

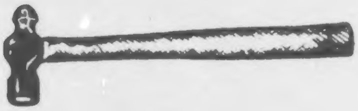


p. ______________________

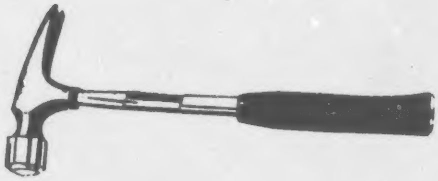


q. ______________________

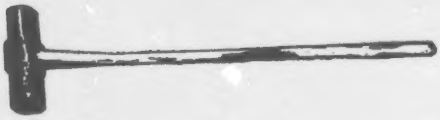
r. ______________________



s. ______________________

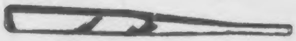


t. ______________________

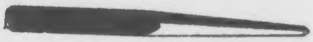


u. ______________________

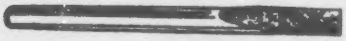
S-60-D



v. ________________

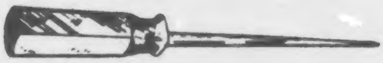


w. ________________

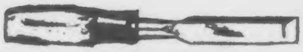


x. ________________

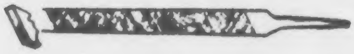
y. ________________



z. ________________



aa. ________________

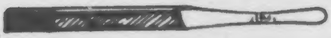


bb. ________________

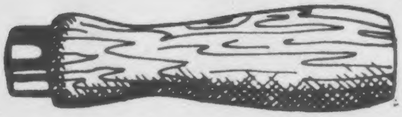
cc. ________________

dd. ________________

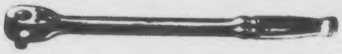
ee. ________________



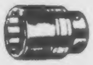
ff. ____________________



gg. ____________________



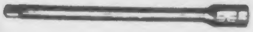
hh. ____________________



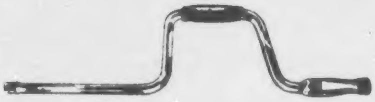
ii. ____________________

jj. ____________________

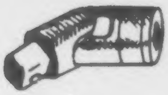
kk. ____________________



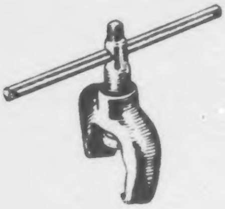
ll. ____________________



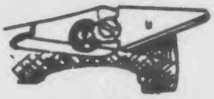
mm. ____________________

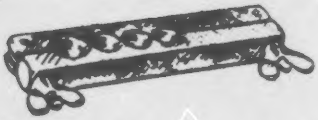


nn. ____________________

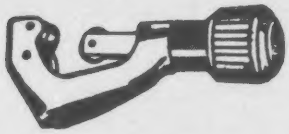


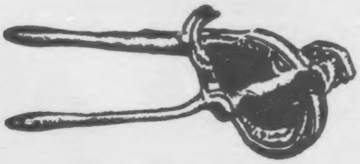
oo. ____________________



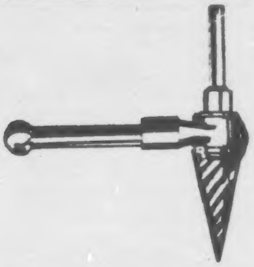


pp. ______________________ qq. ______________________

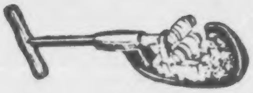


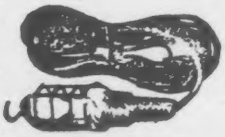


rr. ______________________ ss. ______________________

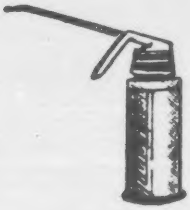


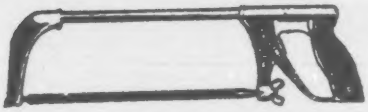
tt. ______________________ uu. ______________________



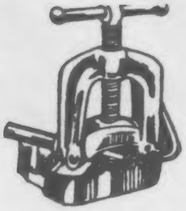


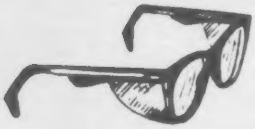
vv. ______________________ ww. ______________________



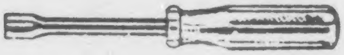


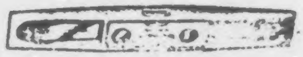
xx. ______________________ yy. ______________________



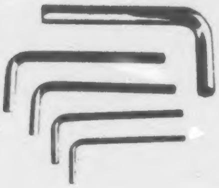


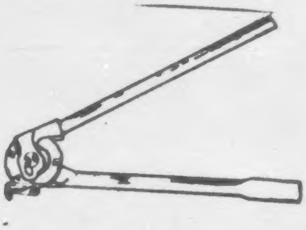
zz. ______________________ aaa. ______________________



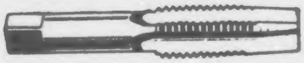


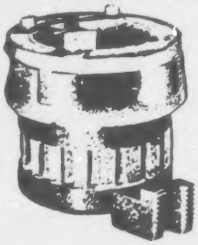
bbb. ______________________ ccc. ______________________



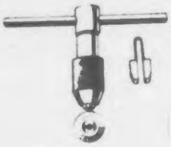


ddd. ______________________ eee. ______________________

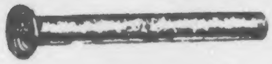




fff. ______________________ ggg. ______________________



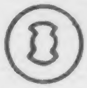
hhh. ______________________ iii. ______________________



jjj. ________________________

3. Select specific tools from similar groups.

a. Place an "X" by the screwdriver that would fit the screw slot shown.



_____1) Standard slot

_____2) Phillips

_____3) Clutch head

_____4) Stubby

_____5) Offset

b. Place an "X" by the wrench that is primarily used on rounded surfaces.

_____1) Open end

_____2) Box end

_____3) Combination box and open end

_____4) Adjustable open end

_____5) Pipe

_____6) Flare nut

c. Place an "X" by the pliers that are used for holding or reaching small items.

_____1) Slip joint

_____2) Slip groove

_____3) Long nose

_____4) Diagonal cutters

_____5) Plier wrench

d. Place an "X" by the hammer that would be used on a brass surface and not mar it.

_____1) Ball peen

_____2) Soft face

_____3) Sledge

_____4) Claw

e. Place an "X" by the item that would be used when making indentations in metal for starting a drill.

_____1) Pin punch

_____2) Center punch

_____3) Flat chisel

_____4) Pry bar

_____5) Scratch awl

f. Place an "X" by the file used generally for cleaning up damaged threads.

_____1) Flat

_____2) Half round

_____3) Round

_____4) Point

_____5) Triangular

_____6) File handle

g. Place an "X" by the items that are not drive handles.

_____1) Ratchet

_____2) Socket

_____3) Deep socket

_____4) Hinge handle

_____5) Extension

_____6) Speed handle

_____7) Universal joint

h. Place an "X" by the items needed to cut a piece of tubing from a roll and flare one end and swage the other end.

_____1) Flaring tool

_____2) Tubing reamer

_____3) Flare block

_____4) Cutter

_____5) Swage punch

_____6) Lever type bender

_____7) Bending spring

i. Place an "X" by the item that should be used on all jobs.

_____1) Drop light

_____2) Oil can

_____3) Hacksaw

_____4) Safety glasses

_____5) Nut drivers

_____6) Level

_____7) Hex key wrenches

j. Place an "X" by the tool that is used for cutting external threads.

_____1) Taps _____2) Dies _____3) Handles

4. Match two tool care statements from the right hand column to the correct hand tool by placing the selected letter in the appropriate space.

a. Screwdrivers

1. ______

2. ______

b. Wrenches

1. ______

2. ______

c. Pliers

1. ______

2. ______

d. Hammers

1. ______

2. ______

e. Punches, chisels, and bars

1. ______

2. ______

f. Files

1. ______

2. ______

g. Socket sets

1. ______

2. ______

h. Tubing tools

1. ______

2. ______

a. Do not use in place of wrenches

b. Keep head ground to prevent mushrooming

c. Grind flat tip square

d. Protect the blade on a hacksaw with a piece of cardboard

e. Do not hammer on screwdrivers

f. Use plenty of cutting oil

g. Keep cutting edges sharp

h. Keep files on a rack

i. Do not hammer or pry with a file

j. Turn adjustables in proper direction

k. Levels should never be dropped

l. Keep handles tight

m. Have handles insulated when working on electrical circuits

n. Do not keep taps and dies loose in a drawer

o. Use the proper type hammer for the job

p. Do not hammer with a wrench

q. Do not use an extension pipe or cheater bar on handle of a ratchet

i. Accessory hand tools
   1. _____
   2. _____

j. Threading tools
   1. _____
   2. _____

r. Oil threads on flaring tool

s. Do not use a handle and extension pipe with thin wall sockets

t. Replace cutting wheel or cutter when dull

5. List four procedures for reading a rule.

   a. ____
   b. ____
   c. ____
   d. ____
   ____

6. List four guidelines for the use and care of rules and steel tapes.

   a. ____
   b. ____
   c. ____
   d. ____

7. Match in proper order the steps involved in cutting and threading iron pipe.

   a. _____
   b. _____
   c. _____
   d. _____
   e. _____
   f. _____
   g. _____

   1. Center die on pipe
   2. Check cutting edges for sharpness
   3. Ream inside of pipe to remove burrs
   4. Determine length of the threaded portion
   5. Secure pipe in vise
   6. Inspect and clean dies before threading

h. ______

i. ______

j. ______

k. ______

l. ______

m. ______

n. ______

7. Cut the pipe
8. Clean chips from dies
9. Lightly file outside cut edge if necessary
10. Clean chips from threads
11. Apply cutting oil while threading
12. Turn die slowly in a clockwise direction
13. Be sure dies are in the die stock properly
14. Remove die by turning counterclockwise

8. Demonstrate the ability to:

    a. Measure lines to the nearest quarter, eighth, and sixteenth of an inch

    b. Read a rule/tape measure

    c. Set up and use a hacksaw

    (NOTE: If the above activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

BASIC HAND TOOLS
UNIT I

ANSWERS TO TEST

1. a. 7
   b. 6
   c. 4
   d. 5
   e. 3
   f. 1
   g. 2
   h. 8
   i. 9

2. a. Standard slot screwdriver
   b. Phillips screwdriver
   c. Reed and Prince screwdriver
   d. Clutch head screwdriver
   e. Stubby screwdriver
   f. Offset screwdriver
   g. Open end wrench
   h. Box end wrench
   i. Combination wrench
   j. Adjustable open end wrench
   k. Flare nut wrench
   l. Pipe wrench
   m. Slip joint pliers
   n. Slip groove pliers
   o. Long nose pliers
   p. Diagonal cutters
   q. Plier wrench
   r. Soft face hammer
   s. Ball peen hammer

t. Straight claw hammer

u. Long handle sledge hammer

v. Pin punch

w. Center punch

x. Flat chisel (cold chisel)

y. Pry bar

z. Scratch awl

aa. Wood chisel

bb. Flat file

cc. Half round file

dd. Round file

ee. Triangular file

ff. Point file

gg. File handle

hh. Ratchet handle

ii. Socket

jj. Deep socket

kk. Hinge handle (break-arm)

ll. Extension

mm. Speed handle

nn. Universal joint

oo. Flaring tool

pp. Tubing reamer

qq. Flaring block

rr. Cutter

ss. Geared ratchet-type bender

tt. Pipe reamer

uu. Swage punch

vv. Pipe cutter

ww. Drop light

xx. Cutting oil or lubricating oil

yy. Hacksaw

zz. Pipe vise

aaa. Safety glasses

bbb. Nut drivers

ccc. Level

ddd. Hex key wrenches

eee. Lever type benders

fff. Tap

ggg. Dies and die head

hhh. Die stock

iii. T-handle tap wrench

jjj. Bending spring

3. a. 3

   b. 5

   c. 3

   d. 2

   e. 2

   f. 5

   g. 2, 3, 5, 7

   h. 1, 2, 3, 4, 5

   i. 4

   j. 2

4. Discussion should include:

   a. Screwdrivers

      1) Grind flat tip square

      2) Do not hammer on screwdrivers

b. Wrenches
   1) Turn adjustables in proper direction
   2) Do not hammer with wrenches

c. Pliers
   1) Do not use in place of wrench
   2) Have handles insulated when working on electrical circuits

d. Hammers
   1) Keep handles tight
   2) Use the proper type hammer for the job

e. Punches, chisels, and bars
   1) Keep cutting edges and points sharp
   2) Keep head ground to prevent mushrooming

f. Files
   1) Keep files on a wall rack
   2) Do not hammer or pry with a file

g. Socket sets
   1) Do not use an extension pipe or cheater bar on the handle of a ratchet
   2) Do not use a handle and extension pipe with thin wall sockets

h. Tubing tools
   1) Oil threads on flaring tool
   2) Replace cutting wheel on cutter when dull

i. Accessory hand tools
   1) Protect the blade on a hacksaw with a piece of cardboard to prevent dulling of the teeth
   2) Levels should never be dropped

j. Threading tools
    1) Use plenty of cutting oil when threading
    2) Do not keep taps and dies loose in a drawer

5. a. Count the divisions in one inch
    b. Determine inches and divisions
    c. Reduce the fraction if possible
    d. Determine the feet and add the inches and fractions of an inch to obtain a correct measurement

6. Any four of the following:
    a. Use the proper length and graduation
    b. Use finest graduation for accuracy
    c. Use a good quality rule
    d. Never bend or distort a steel rule
    e. Use only for intended purpose
    f. Rewind steel tapes slowly

7. a. 5
    b. 7
    c. 3
    d. 9
    e. 6
    f. 2
    g. 13
    h. 1
    i. 12
    j. 11
    k. 4
    l. 14
    m. 10
    n. 8

8. Performance skills evaluated to the satisfaction of the instructor.

SOLAR TECHNICIAN'S TOOL BOX
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify those tools which should be included in a solar-technician's tool box. The student should also be able to select true statements about the use and care of each tool and list safety precautions to be taken when using these tools. This knowledge will be evidenced by scoring 85 percent on the unit test.

(NOTE: The student must score 100 percent on the safety section of the test.)

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with a solar-technician's tool box to the correct definitions.
2. Identify tools usually found in a solar-technician's tool box.
3. Select true statements about the use and care of tools usually found in the solar technician's tool box.
4. List three safety precautions applied to the use of tools usually found in a technician's tool box under each of the areas dealing with the condition of tools, work area, handling tools, and storing tools.

SOLAR TECHNICIAN'S TOOL BOX
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information sheet.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Show and explain uses for various tool boxes available to the solar technician

  G. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Types of Handsaws

    2. TM 2--Files and Measuring Tools

    3. TM 3--Levels, Plumb Bob, and Chalk Line

    4. TM 4--Chisels and Punches

    5. TM 5--Drilling and Boring Tools

    6. TM 6--Wrenches

7. TM 7--Wrenches (Continued)
8. TM 8--Screwdrivers and Pliers
9. TM 9--Hammers
10. TM 10--Tubing Cutters
11. TM 11--Copper Tubing Tools
12. TM 12--Straight Snips, Pipe Taps, and Putty Knife
13. TM 13--Eye Protection

D. Test

E. Answers to test

II. References:

A. Blankenbaker, E. Keith. Modern Plumbing. South Holland, Illinois: The Goodheart-Willcox Company, Inc., 1978.

B. Bureau of Naval Personnel. Tools and Their Uses. Washington, D.C.: U.S. Government Printing Office,1971.

SOLAR TECHNICIAN'S TOOL BOX
UNIT II

INFORMATION SHEET

I. Terms and definitions

   A. Repair tools--Those tools, including special tools, which are used for repair of collectors, valves, pumps, and other system components

   B. Installation tools--General construction tools which consists of small tools provided by the worker and more expensive tools provided by the employer

   C. Specialty tools--Expensive tools or tools used for a specific purpose, usually provided by the employer

   D. Hand tools--Hand held tools used for common plumbing jobs, usually owned by the solar technician

II. Tools for the technician's tool box

   A. Saws (Transparency 1)

      1. Hacksaw

      2. Jabsaw

      3. Compass or keyhole saw

      4. Handsaw

      5. Miter saw

   B. Files (Transparency 2)

      1. Flat

      2. Round

      3. Triangular

      4. Rasp

   C. Measuring tools (Transparency 2)

      1. Folding rule

      2. Tape measure

D. Levels (Transparency 3)
   1. 24" carpenter's
   2. Torpedo

E. Plumb bob and line (Transparency 3)

F. Chalk line (Transparency 3)

G. Chisels and punches (Transparency 4)
   1. Set of cold chisels
   2. Set of wood chisels
   3. Nail set
   4. Set of pin punches
   5. Center punch

H. Drilling and boring tools (Transparency 5)
   1. Drilling tools
      a. Hand drilling machine
      b. Set of high speed drills
      c. Set of small masonry drills
      d. Star drill
   2. Boring tools
      a. Ratchet brace
      b. Set of wood bits (1/2", 3/4", 1")

I. Wrenches (Transparency 6)
   1. Set of straight pipe wrenches (8", 12", 14", 18")
   2. 14" offset pipe wrench
   3. 8" adjustable wrench
   4. Set of open end wrenches
   5. 8" plier wrench (vise grips)
   6. Set of flare nut wrenches

    7. Set of socket wrenches and ratchet
    8. Internal wrench--(Transparency 7)

J. Pliers (Transparency 8)

    1. Needlenose pliers
    2. 14" adjustable pliers
    3. 10" adjustable pliers
    4. Combination slip-joint pliers
    5. Dykes (lineman's pliers)

K. Screwdrivers (Transparency 8)

    1. Set of phillips head screwdrivers
    2. Set of straight tip screwdrivers
    3. Offset screwdriver

L. Hammers and nail pullers (Transparency 9)

    1. 20 oz. straight claw hammer
    2. 16 oz. ball peen hammer
    3. Sledge hammer
    4. Nail puller (cats-paw)

M. Tubing cutters (Transparency 10)

    1. Small diameter tubing cutter (1/8" - 1")
    2. Small quick opening tubing cutter (1/4" - 1 1/8")
    3. Large tubing cutter (1/4" - 3 1/8")
    4. Close tubing cutter (1/2", 3/4")
    5. Internal cutters

N. Copper tubing tools (Transparency 11)

    1. Striker
    2. Flux brush
    3. Clean towel

4. Sandcloth

5. Pocket knife

6. Yoke and screw flaring tool

7. Hammer flaring tool

8. Swaging tool

9. Set of copper fitting brushes

10. Tubing bender - 1/2", 3/4"

a. Lever type bender

b. Geared ratchet type bender

11. Spring bender--3/8", 7/16", 1/2", 5/8"

O. Pair of straight snips (Transparency 12)

P. Pipe taps (1/8" - 1")--(Transparency 12)

Q. Putty knife (Transparency 12)

R. Eye protection (Transparency 13)

1. Safety glasses

2. Goggles

3. Face shield

III. Use and care of tools

A. Handsaws (Transparency 1)

1. Saw blade should be kept dry and lightly oiled

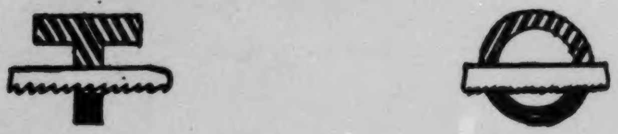
2. If possible, a protective guard should be kept on the cutting edge when not being used

3. Most saws cut on the forward stroke; release downward pressure on the return (or back) stroke

4. Number of teeth per inch (points indicate how fine a cut the saw will make (Figure 1)

(NOTE: At least two teeth should be on the work piece at all times while cutting.)

FIGURE 1



24 Teeth per inch

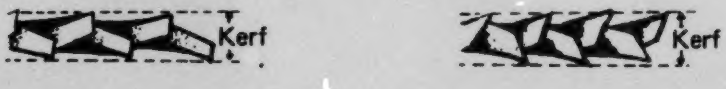
For angle iron, heavy pipe, brass, copper

32 Teeth per inch

For thin tubing

5. Type of saw tooth and set of tooth is important to the cut being made (Figure 2)

FIGURE 2



Top view of rip teeth

Teeth of rip saw

Top view of crosscut teeth

Teeth of crosscut saw

6. A used blade makes a more narrow cut than a new blade, therefore do not use a new blade in an old cut

B. Files (Transparency 2)

1. Filing must be done flat, not in a "rocking" motion

2. Filing should be done in long, slow strokes; the harder the metal is, the slower the stroke should be

   (NOTE: Use the whole length of the file. See Figure 3)

3. Files, like hacksaws, cut only on the forward stroke

   (NOTE: The cutting edges of the file can be worn down by applying too much pressure on the back stroke.)

4. Always use a handle on a file (Figure 4)

FIGURE 4

If you had put a handle on the file, you wouldn't need a bandage now!

5. File should be cleaned with a file card or brush

6. Rasps are wood files used to enlarge pipe holes

C. Measuring tools (Transparency 2)

1. Measurements must be accurate to the fraction of an inch and instruments must be capable of such accuracy

2. Folding rules should have a small amount of fine oil applied to the joints in order to lessen wear

   (NOTE: Loose joints can cause inaccuracies in measurement; each joint inaccuracy can multiply over the length of the rule.)

3. Joints can be loosened by dropping the rule on its end

4. Use care in handling wooden rules; they can break easily and are expensive

   (NOTE: Avoid buying cheap rules; they break very easily.)

5. Steel tapes must be kept clean and lightly oiled

   (NOTE: Dirt and other abrasives wear away the numbers and cause destruction of the rewinding mechanism.)

6. Rewinding tape slowly can avoid breakage and excessive wear

D. Levels (Transparency 3)

1. Vials (tubes) can easily be broken, causing the level to become useless

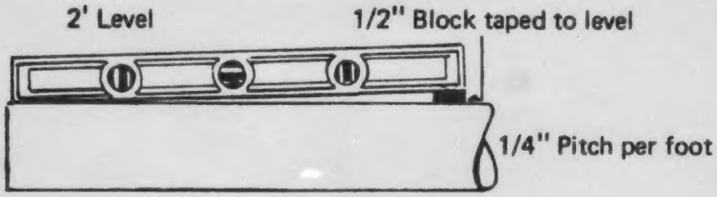
2. Occasionally run a flat file over the surface of a metal level to remove burrs

   (NOTE: Levels should be treated with so much care that no burrs ever develop.)

3. Wooden levels should be kept dry to avoid splinters and warping

4. Levels can be adjusted to determine correct pitch of pipes (Figure 5)

   FIGURE 5



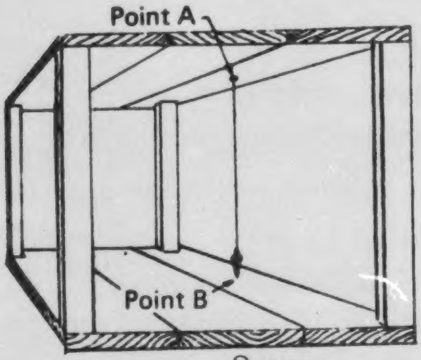
5. Torpedo levels are hand 9" levels which fit into a small tool box

   (NOTE: Keep surfaces free of burrs to allow accurate readings.)

E. Plumb bob and line (Transparency 3)

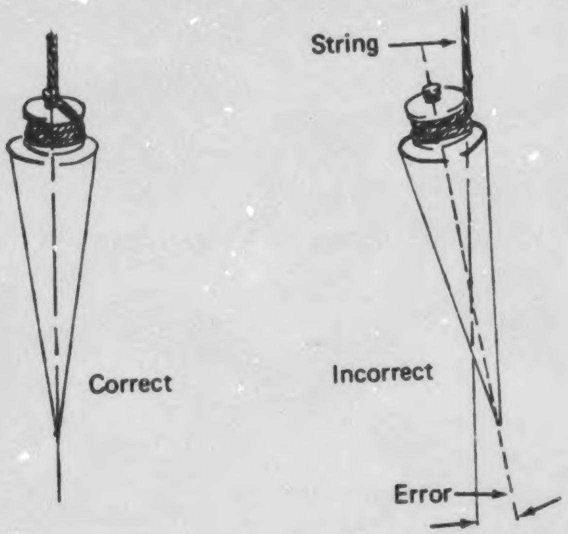
1. Used to locate the center of vertical runs and transfer the point from one floor level to another (Figure 6)

   FIGURE 6



2. The point of the plumb bob must hang directly below the string in a vertical plane (Figure 7)

FIGURE 7



3. Rounded or bent points can cause inaccurate measurements

4. The line must be of good quality to avoid breakage or excessive wear

   (CAUTION: Do not look directly up at a hanging plumb bob or allow anyone else to do so.)

5. In order to establish an accurate measurement the following steps must be observed:

   a. The line must be stretched tightly

   b. The line must not be allowed to touch some object between the two points

   c. The plumb bob must not be swinging when the measurement is taken

   d. The plumb bob can rest on the surface, be lifted slightly, and then rest again to determine an accurate location

F. Chalk line (chalk box) (Transparency 3)

   1. Chalk lines must be kept dry

   2. Different colored chalk can be used for specific purposes

3. The most common use is to lay out wall locations for piping installation

4. The chalk box must be refilled with chalk periodically

G. Chisels and punches (Transparency 4)

1. Cold chisels are used to cut cold metal and are made in a variety of shapes: falt, cape, diamond point, round nose

   (NOTE: The flat chisel is the most useful as a general purpose chisel.)

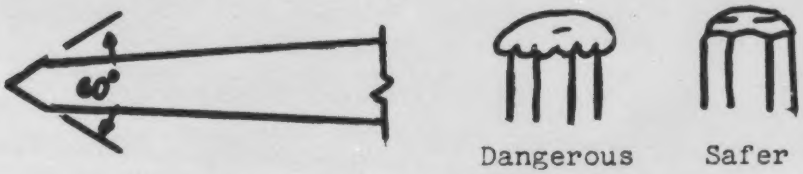
2. Chisels and hammers should be held loosely but firmly in order to "bounce" the chisel as it is struck

   (NOTE: Holding the chisel and hammer tightly will cause the worker to absorb the shock of the blow.)

3. Wear goggles when using chisels

4. The cutting edge of cold chisels should be kept sharp and the head clean and tapered (Figure 8)

   FIGURE 8



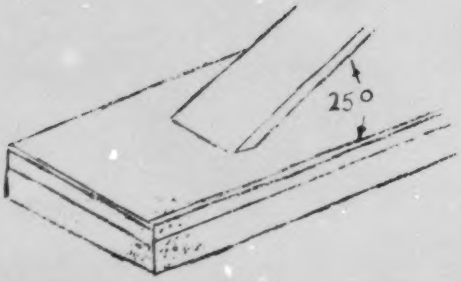
Dangerous Safer

5. Steel chisels for wood can be purchased in sets or individually

6. Wood chisels are used to trim openings and make notches for pipe

7. Wood chisels are ground to a 25° angle and must be periodically honed and oiled in order to maintain a sharp edge (Figure 9)

FIGURE 9



8. Pin punches of 1/8", 1/4", and 3/8" are useful in punching holes in metal or other material and in dislodging corroded parts

9. Center punches are used to make starting points for drilling metal

H. Drilling tools (Transparency 5)

1. Hand drilling machines are useful for small jobs when electricity is unavailable

2. A ratchet brace is especially useful when electricity is unavailable

   (NOTE: These tools must be cleaned and oiled after use.)

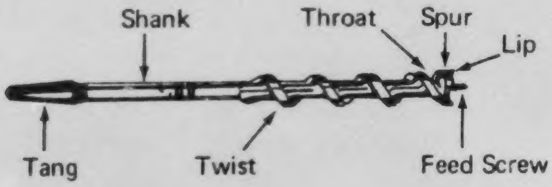
3. Small masonry drills 1/8" to 1/2" are valuable for making holes in brick or concrete for anchor bolts

4. High speed steel drills are useful in cleaning and enlarging holes in metal and other materials, and also for drilling new holes

   (NOTE: High speed steel (HSS) is used in the manufacture of these drills.)

5. Wood bits (auger bits are designed to be used in a ratchet brace (Figure 10)

FIGURE 10



6. Expansive wood drills allow a variety of hole sizes to be drilled with a single drill

I. Wrenches (Transparencies 6 and 7)

1. Small pipe wrenches are handy for small pipe and round objects, especially in tight places

2. Offset pipe wrenches are useful in working in corners and other tight places

3. Adjustable wrenches are useful because they can replace several different sizes of open end wrenches

   (NOTE: All wrenches should be kept dry and lightly oiled.)

4. Open-end wrenches are useful because they are not likely to slip off an object when being used

   (NOTE: Wrenches that have damaged or "spread" jaws should be discarded.)

5. Plier wrenches (vise grips) are always handy when square or hex shoulders have been worn away and when working in tight quarters

   (NOTE: Plier wrenches should not be used where scratches from jaw teeth create an unsightly installation.)

6. Flare nut wrenches are useful when tightening or loosening a flare nut because the end of the open end wrench can easily slip over the tubing

7. Socket wrenches are necessary when working with nuts and bolts where adjustable or open end wrenches cannot gain access

8. Internal wrenches are useful in installing close nipples without damage to threads

J. Pliers (Transparency 8)

1. Needlenose pliers are very helpful in such instances as retrieving loose parts and repairing drop lights and extension cords

   (NOTE: Pliers should be cleaned and periodically oiled.)

2. Adjustable pliers are useful in turning difficult to open locknuts

K. Hammers and nail pullers (Transparency 9)

1. A claw hammer is a necessary tool when preparing a wood frame structure for piping installation or framing members might need to be moved or revised

   (CAUTION: Hammers with worn faces should not be used.)

L. Screwdrivers (Transparency 8)

1. Phillips head screwdrivers are used in fixture installation since most screws on fixture trim are phillips head screws

   (NOTE: Discard worn phillips head screwdrivers.)

2. Straight tip screwdrivers are used for various jobs

M. Tubing cutters (Transparency 10)

1. Technicians should provide their own cutters to cut tubing up to and including 1", and the employer should, when necessary, provide larger cutters

   (NOTE: Cutting wheels and rollers should be oiled periodically and cutting wheels replaced when needed.)

2. Close tubing cutters are available for cutting tubing in close quarters

N. Copper tubing tools (Transparency 11)

1. Strikers, which provide sparks for torch lighting, should be kept dry, clean, and free from oil

   (NOTE: Extra flints for the striker should be kept in the tool box.)

2. Flux brushes are helpful in making a clean application of flux to pipe and fitting

   (NOTE: Special flux brushes are available at stores, or old tooth brushes can be used.)

3. A good supply of clean wiping cloths should be available to the worker for cleaning pipes and soldered joints

4. Sand cloth, emery paper, or steel wool is necessary to clean oxidized surfaces of copper pipe and fittings prior to applying flux

5. A pocket knife is used for reaming large size copper tubing and plastic pipe, cutting plastic pipe, and many other uses

   (CAUTION: Carelessness in using a pocket knife has caused many injuries and lost work hours.)

6. Flaring tools, which are used for making mechanical joints, should be cleaned and oiled periodically

7. Hammer flaring tools are used to make joints on copper-water lines

   (NOTE: Keep tool clean and lightly oiled at all times.)

8. Swaging tools save the expense of fittings by enlarging tubing ends to act as couplings

   (NOTE: Keep tool clean and lightly oiled at all times.)

9. Fitting brushes do an excellent job of cleaning small fittings in preparation for soldering

   (NOTE: Turn fitting brushes in clockwise direction as counterclockwise will reduce the effectiveness of the brushes.)

10. Tubing benders should be returned to their proper places immediately after use

O. Snips (Transparency 12)-Snips (straight aviation types are best) are a useful tool in performing jobs such as cutting vent pipe or flashing

(NOTE: Do not cut wire with snips.)

P. Pipe taps (Transparency 12)

1. Pipe taps are used to repair damaged threads

2. Keep taps clean and oiled at all times

Q. Putty knives (Transparency 12)--Putty knives are useful in applying roofing pitch around flashing and collector pipe opening through roof and/or walls

R. Eye protection (Transparency 13)

1. Safety glasses are special glasses approved by the Federal Food and Drug Administration (FDA) after passing an impact resistance test; they are shatterproof and the frames are stronger

   (NOTE: Safety glasses can be identified by manufacturer's symbols on both the lenses and frames.)

2. Goggles are made of a flexible plastic body and lens and provide protection from dust, flying particles, and splashed liquids

   (CAUTION: Goggles must be worn over prescription lenses.)

3. Face shields protect the whole face from flying chips and splashed liquids

IV. Safety precautions while handling tools

A. Condition of tools

1. Tools should be kept clean
2. Tools should be free of grease and excess oil
3. Tool which can rust should be lightly oiled
4. Keep handles on files
5. Keep chisel ends trimmed and dressed
6. Drop cords and extension cords should be in good repair
7. Cutting tools should be kept sharp in order to prevent forcing or causing the worker to become impatient
8. Do not use a weak or damaged ladder

B. Work area

1. Keep work area clean

   (NOTE: If necessary, clean the area before starting work.)

2. Carry to the work area only those tools that you will need

3. Lay out your tools in an orderly fashion

4. Provide ample room to work; do not struggle around objects which can be moved

5. Keep such items as gas hoses and electric cords neat and orderly and not in a tangled mess

6. Clean the work area before leaving

C. Handling tools

   1. Keep tools in their proper places

   2. Sharp instruments such as screwdrivers should not protrude from pockets

   3. Tools should be handed to one another, not thrown or tossed

   4. Electric cords should be kept out of water

   5. Gloves should be worn as a protection against heat and flying chips

   6. Eye and face protection should be used when working with certain tools

   7. Hands should be washed after handling tools and before eating

D. Storing tools

   1. Tools should be stored properly in order to provide ease and safety in picking up and putting away

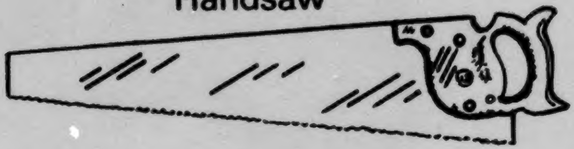
   2. Heavy tools should be stored near the floor, light tools in higher positions

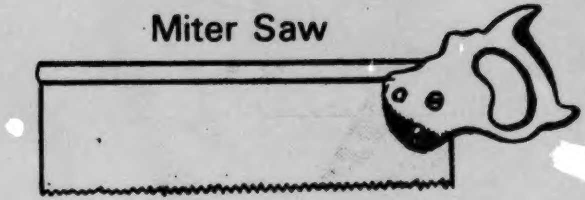
   3. Attempt to store all tools off the floor in order to avoid dangerous floor space

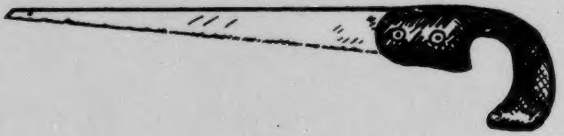
4. Large tools and heavy tool boxes should be moved by two or more people

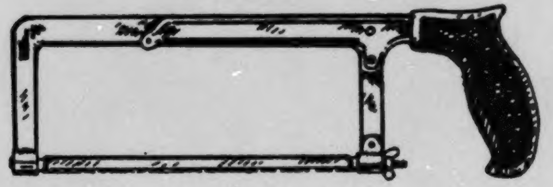
   (NOTE: Use of excessive energy for simple jobs promotes fatigue, impatience, and invites accidents.)

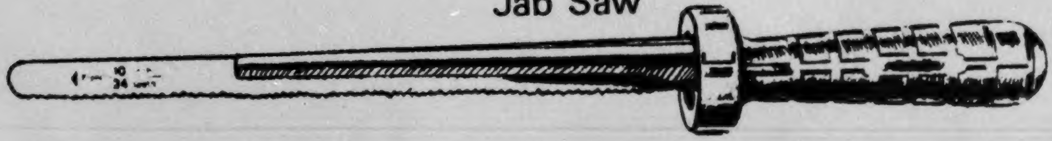
Types of Handsaws


Handsaw


Miter Saw

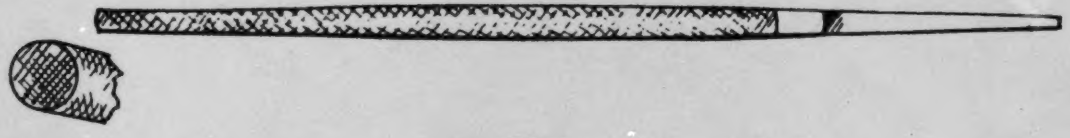

Compass or Keyhole Saw


Hacksaw

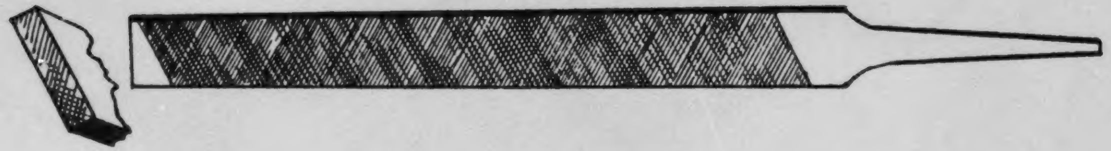

Jab Saw

Files and Measuring Tools

Round

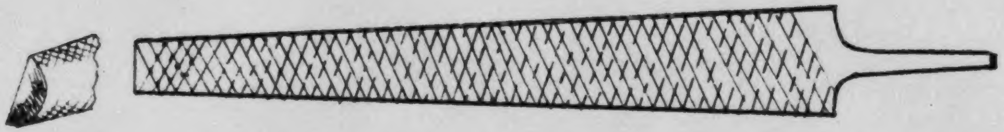


Flat

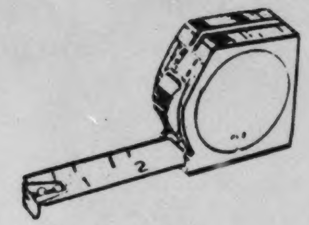


Triangular

Rasp



Folding Rule

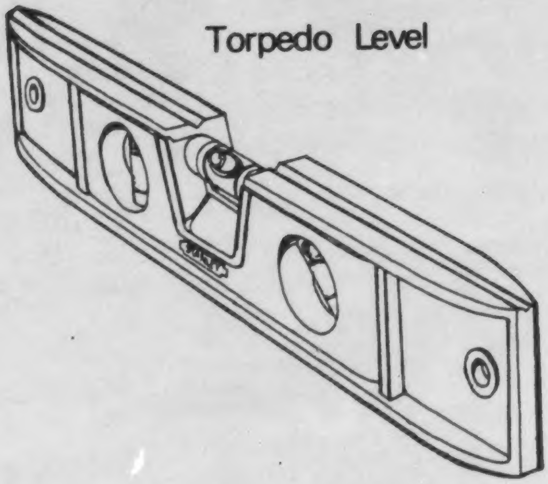


Tape Measure

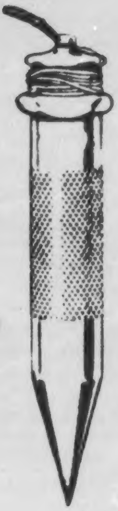
Levels, Plumb Bob, and Chalk Line

24" Carpenter's Level

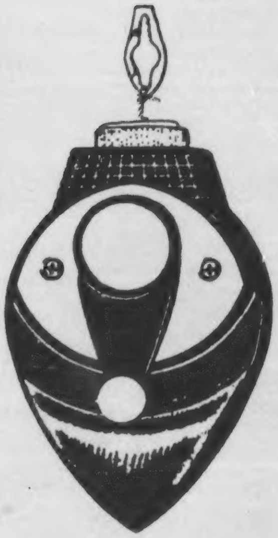
Torpedo Level



Plumb Bob
and Line

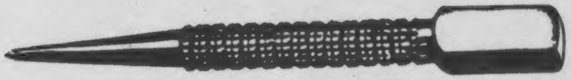


Chalk Line

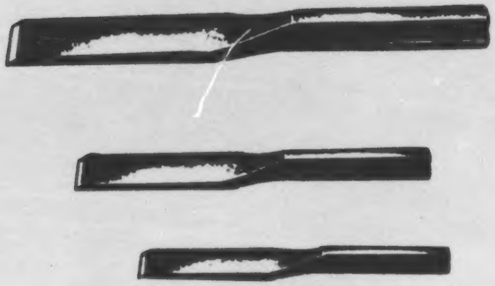


Chisels and Punches

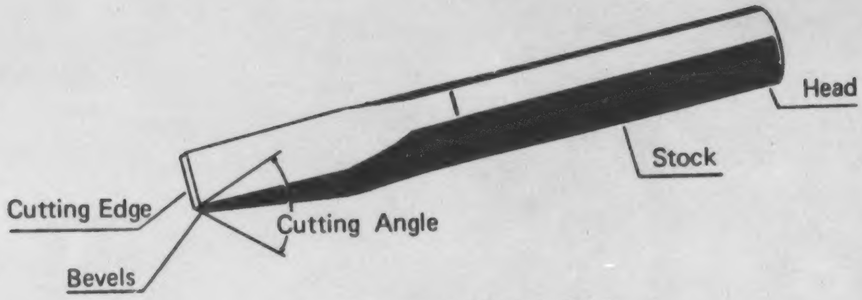
Nail Set



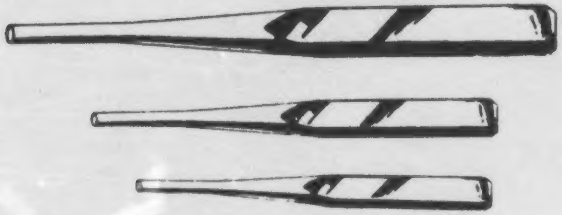
Center Punch



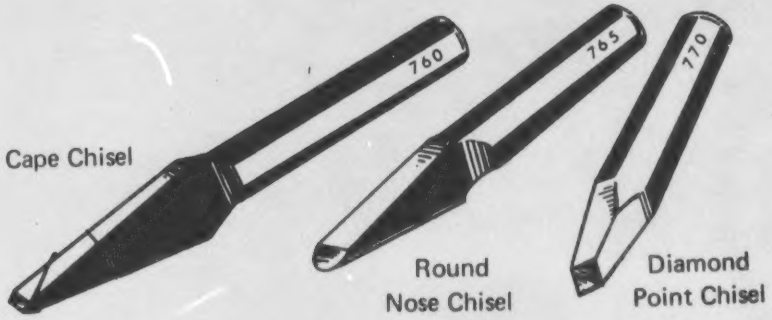
Set of Wood Chisels



Parts of a Cold Chisel



Set of Pin Punches



Set of Cold Chisels

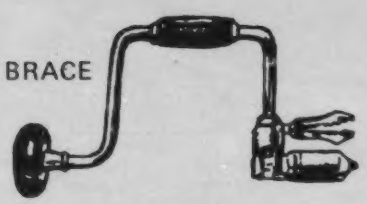
Illustrations of nail set, center punch, and cold chisels courtesy of Stanley Tools.

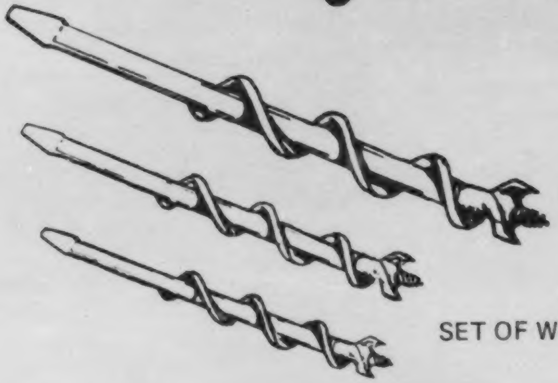
TM 4

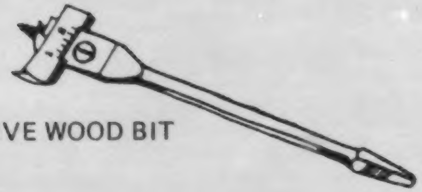
S-105-D

Drilling and Boring Tools

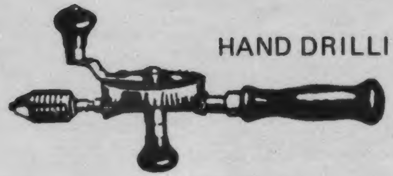
Boring Tools

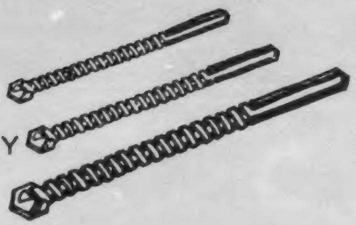

RATCHET BRACE

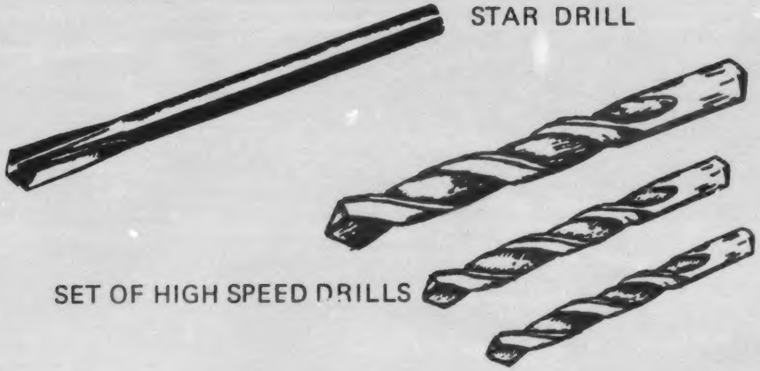

SET OF WOOD BITS


EXPANSIVE WOOD BIT

Drilling Tools


HAND DRILLING MACHINE

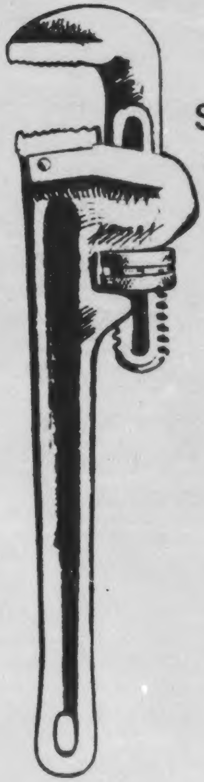

SET OF SMALL MASONRY DRILLS

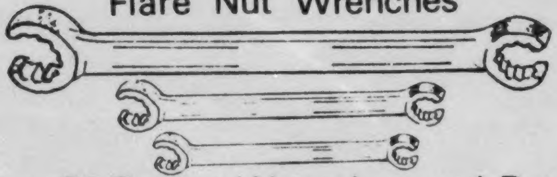

STAR DRILL

SET OF HIGH SPEED DRILLS

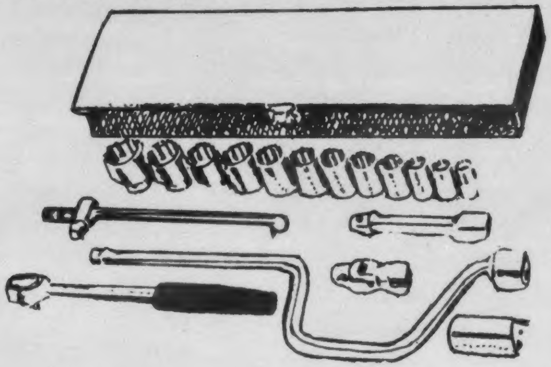
TM 5

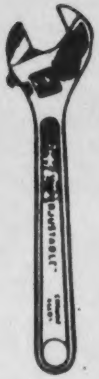
Wrenches


Straight Pipe Wrench

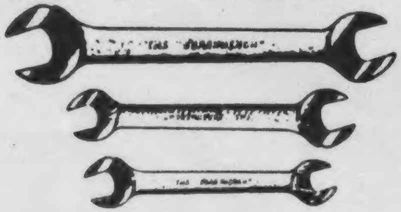

Flare Nut Wrenches

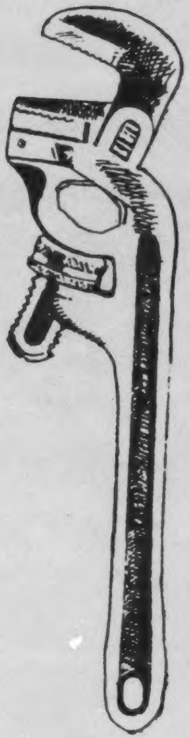
Set Of Socket Wrenches and Ratchet

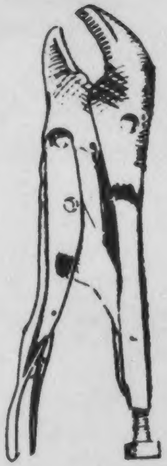



8" Adjustable Wrench

Set of Open-End Wrenches




14" Offset Pipe Wrench


8" Plier Wrench

(Vise Grips)

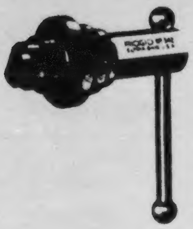
TM 6

S-109-D

Wrenches

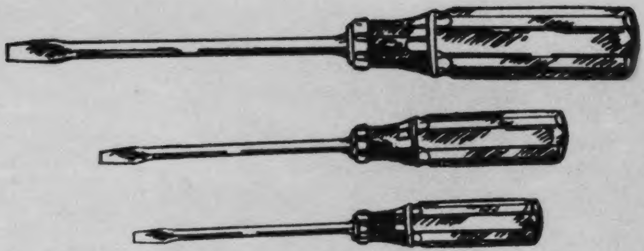
(Continued)

Internal Wrench

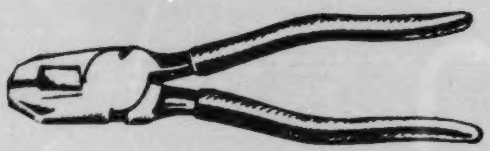


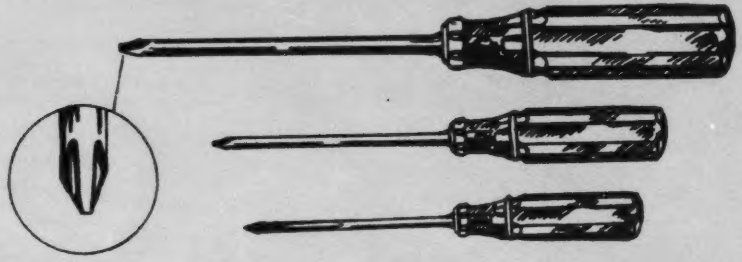
Screwdrivers and Pliers

Combination Slip-Joint Pliers

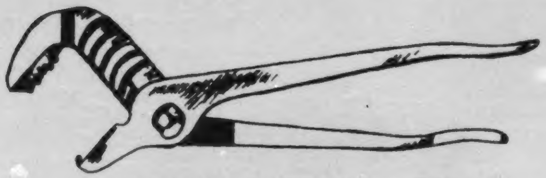

Set of Straight Tip Screwdrivers

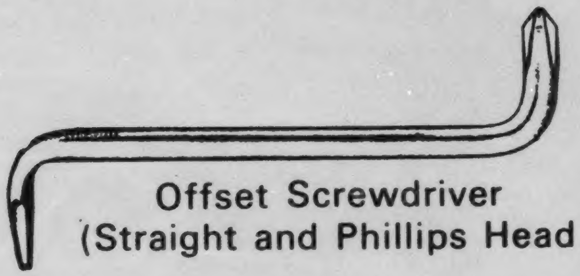
Needlenose Pliers


Dykes (Lineman's Pliers)

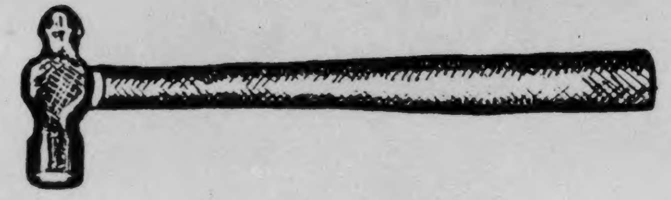

Set of Phillips Head Screwdrivers

10" Adjustable Pliers

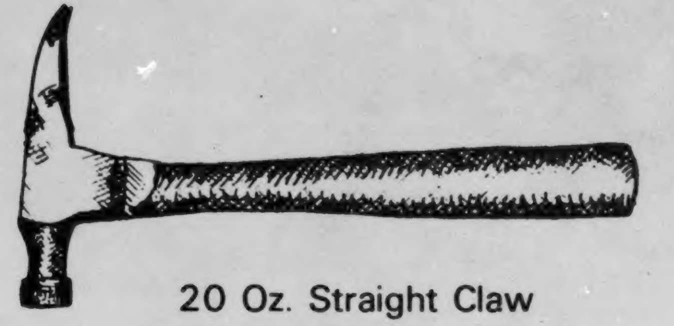

14" Adjustable Pliers


Offset Screwdriver
(Straight and Phillips Head)

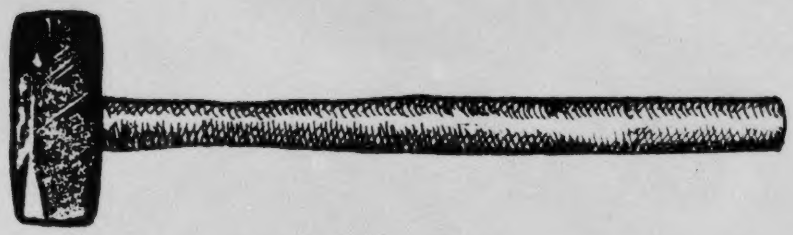
Hammers



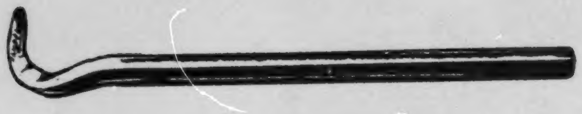
16 Oz. Ball Peen



20 Oz. Straight Claw

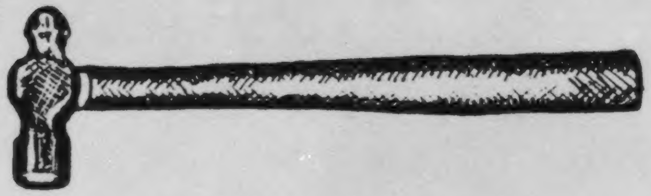


Sledge Hammer

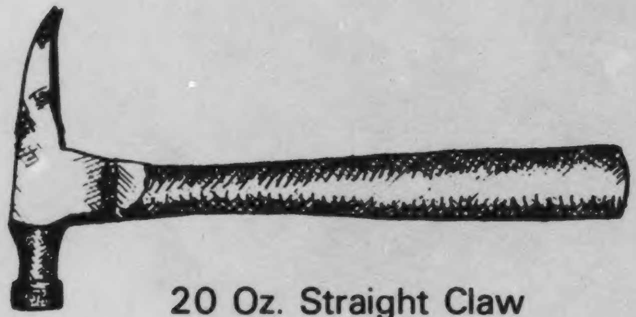


Nail Puller (Cat's-Paw)

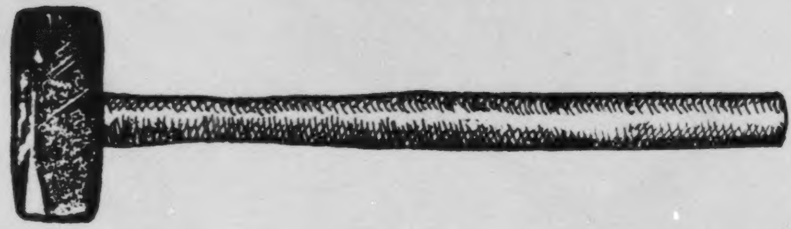
Hammers



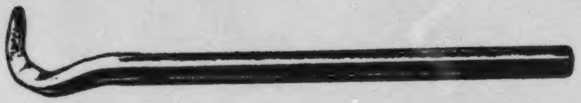
16 Oz. Ball Peen



20 Oz. Straight Claw



Sledge Hammer

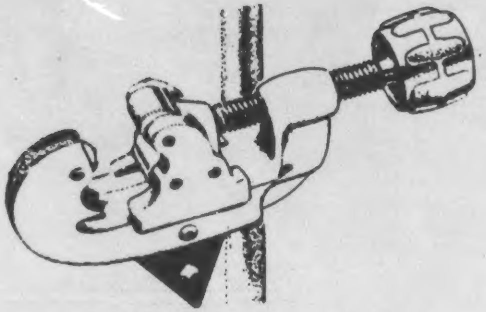


Nail Puller (Cat's-Paw)

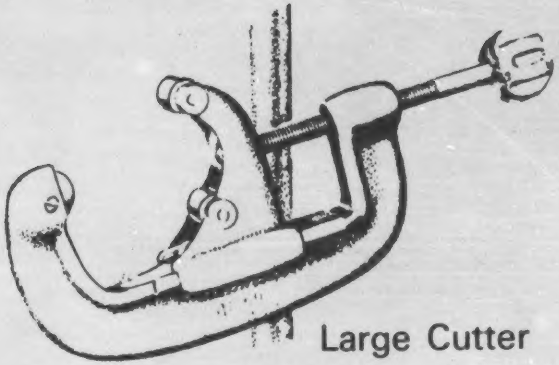
TM 9

S-115-D

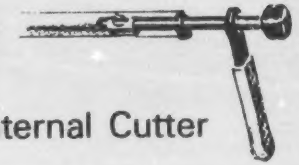
Tubing Cutters



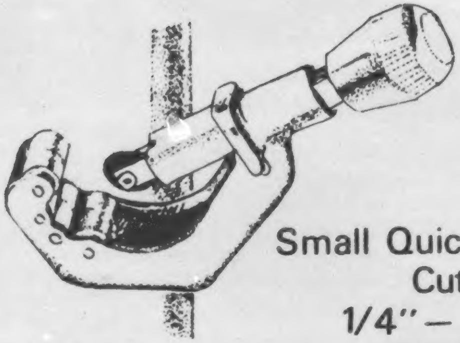
Small Diameter Cutter
1/8"–1"



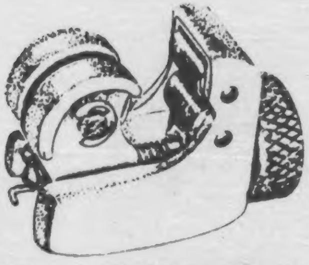
Large Cutter
1/4" – 3 1/8"



Internal Cutter



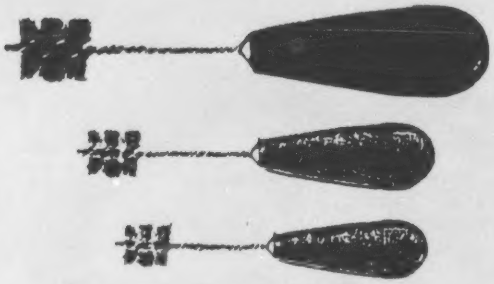
Small Quick-Opening
Cutter
1/4" – 1 1/8"

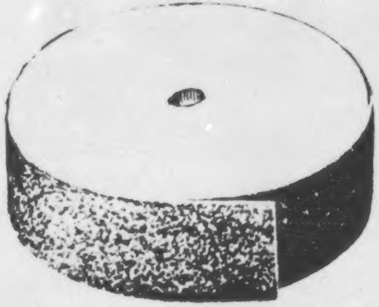


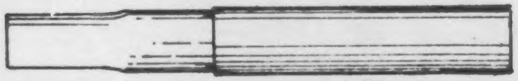
Close Tubing Cutter
(Mini-Cutter)
1/2"–3/4"

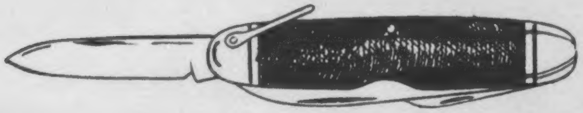
Copper Tubing Tools

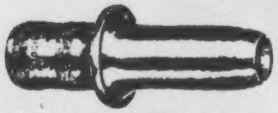
Striker

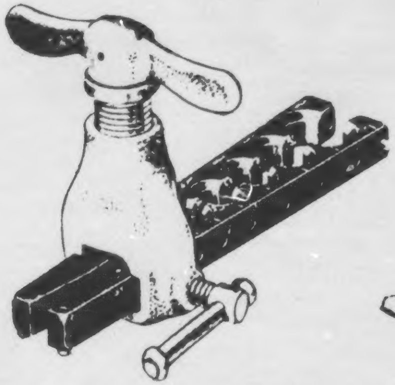

Set of Copper Fitting Brushes


Sandcloth

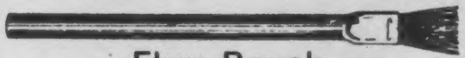

Swaging Tool

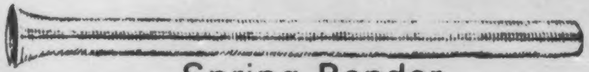

Pocket Knife

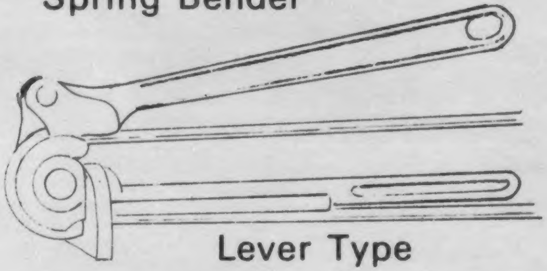

Flaring Tool Hammer Type

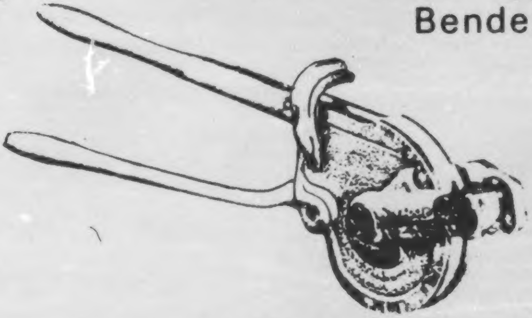

Yoke and Screw Flaring Tool

Shop Towel


Flux Brush


Spring Bender

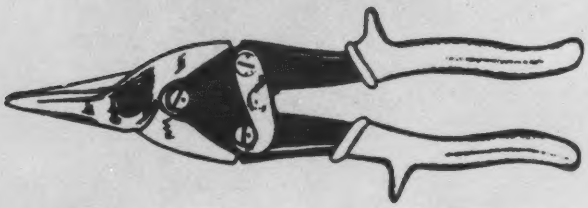

Lever Type Bender


Geared Ratchet Type Bender

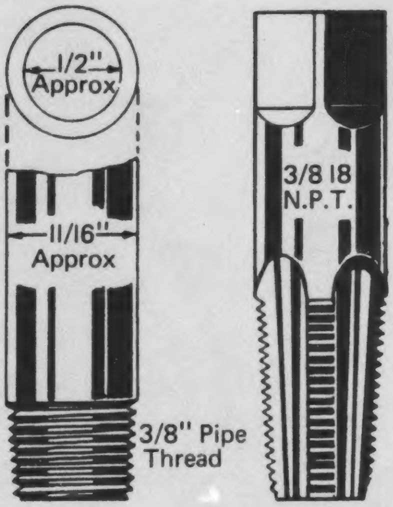
TM 11

S-119-D

Straight Snips, Pipe Taps, and Putty Knife



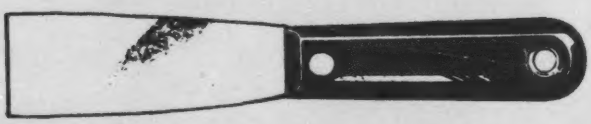
Pair of Straight Snips



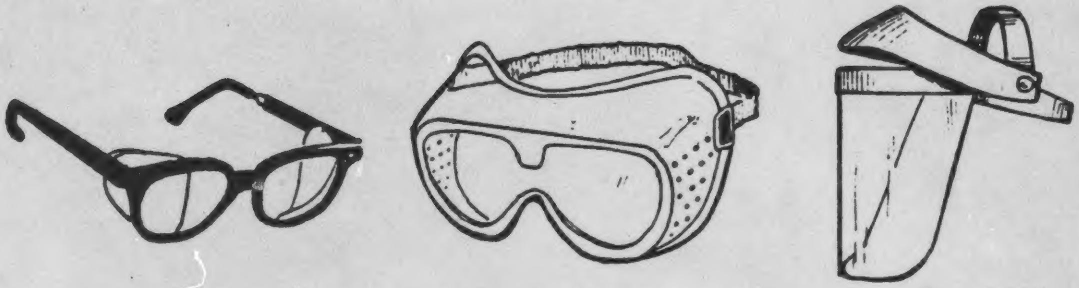
3/8" Pipe

3/8" Pipe Tap
44.154

Pipe Taps



Putty Knife



Safety Glasses

Goggles

Face Shield

Eye Protection

SOLAR TECHNICIAN'S TOOL BOX
UNIT II

NAME________________________

TEST

1. Match terms on the right to the correct definitions.

_____a. Those tools, including special tools, which are used primarily for reconditioning of piping systems, valves, faucets, fixtures, and other components

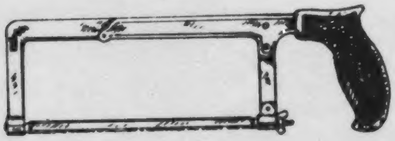
_____b. General construction tools which consist of small tools provided by the worker and more expensive tools provided by the employer

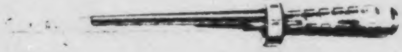
_____c. Expensive tools or tools used for a specific purpose, usually provided by the employer

_____d. Hand held tools used for common installation jobs, usually owned by the technician

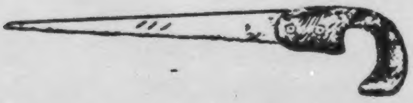
1. Installation tools
2. Specialty tools
3. Repair tools
4. Hand tools

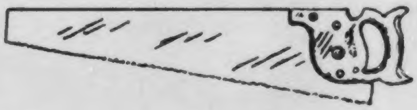
2. Identify tools usually found in a solar technician's tool box



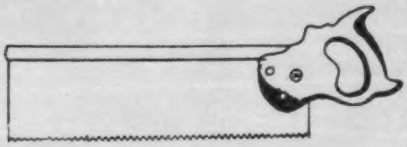


a. ____________________ b. ____________________

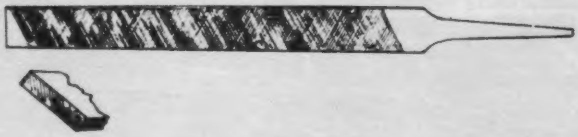




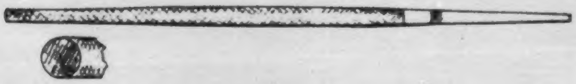
c. ____________________ d. ____________________



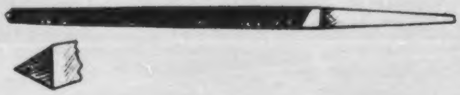
e. ______________________________



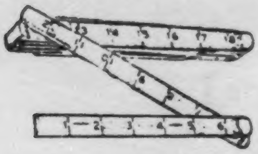
f. ______________________________



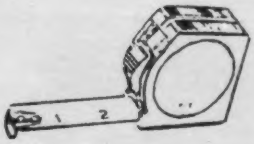
g. ______________________________



h. ______________________________



i. ______________________________



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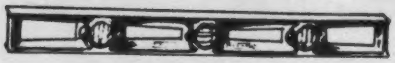
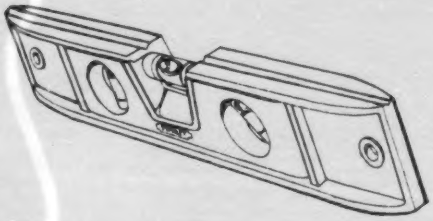
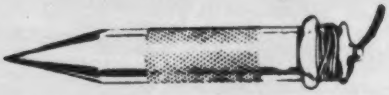


k. ______________________________



l. ______________________________



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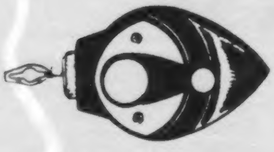

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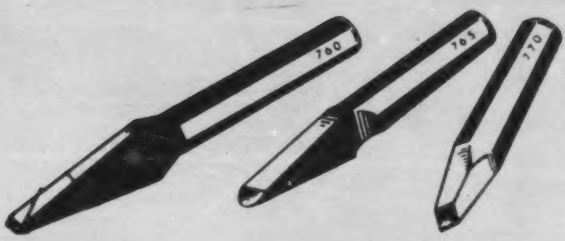
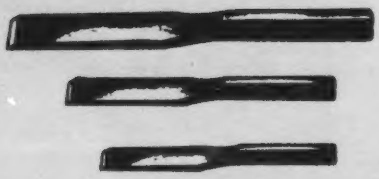


o. ____________________



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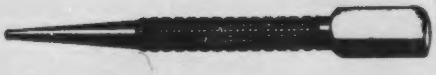
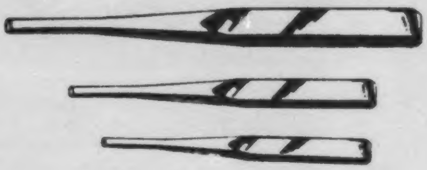
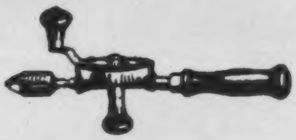


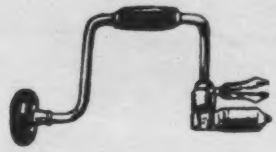
q. ____________________



r. ____________________



s. ____________________



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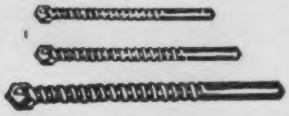

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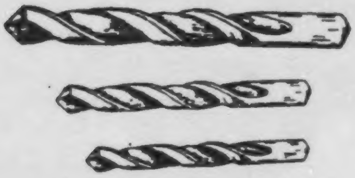
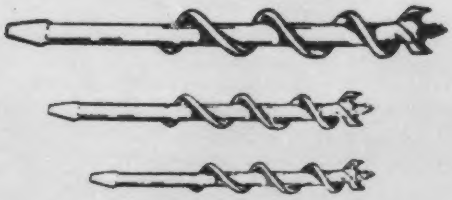


v. ____________________



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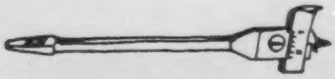
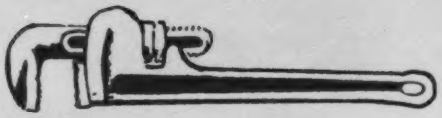
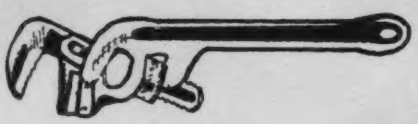


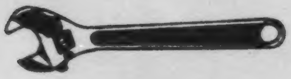
x. ____________________

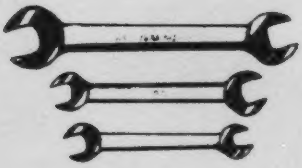




y. ______________________

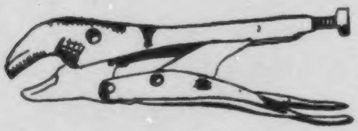
z. ______________________

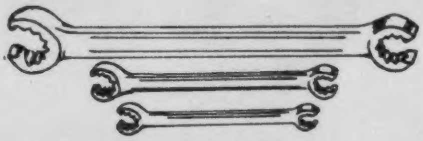




aa. ______________________

bb. ______________________





cc. ______________________

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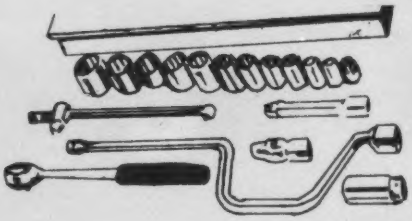
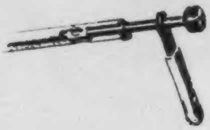
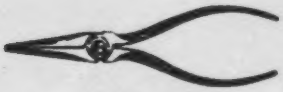
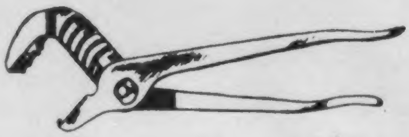




ee. ______________________

ff. ______________________





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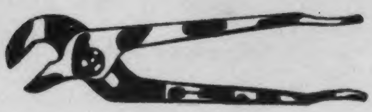
hh. ______________________



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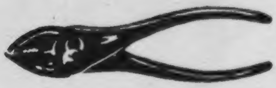

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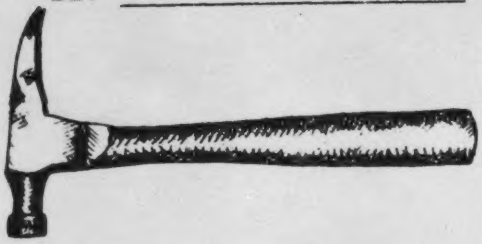

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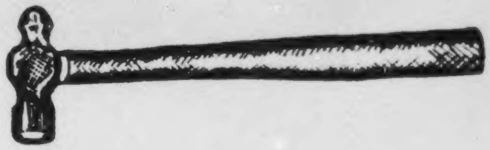
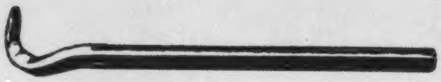
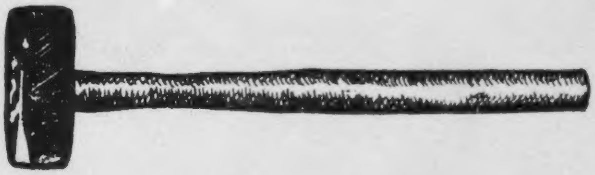


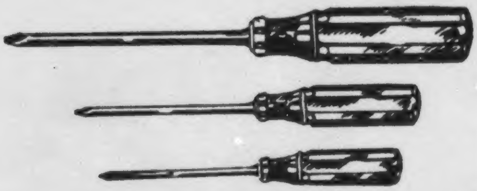
ll. ____________________



mm. ____________________



nn. ____________________



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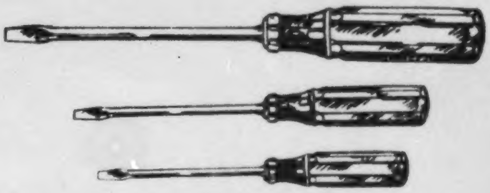

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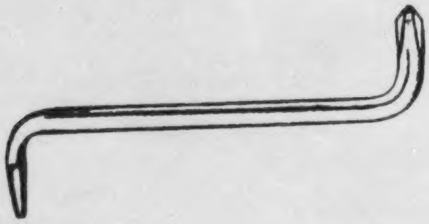

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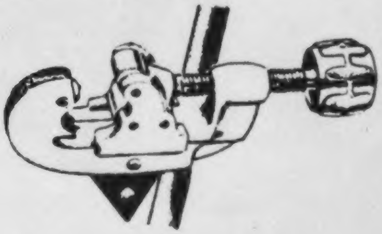

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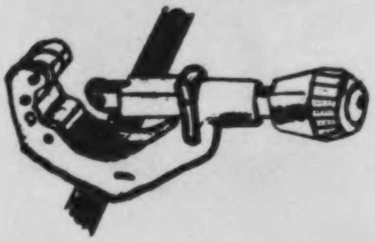

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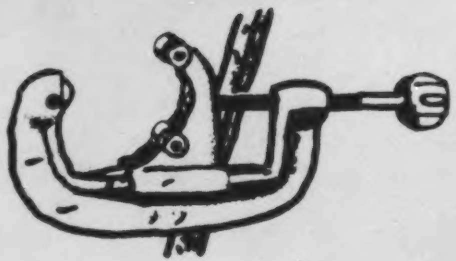

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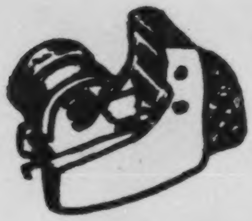

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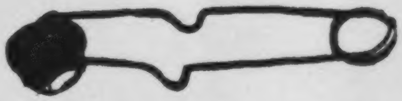
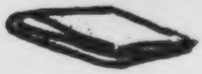


vv. ____________________

ww. ____________________



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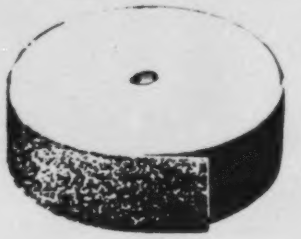

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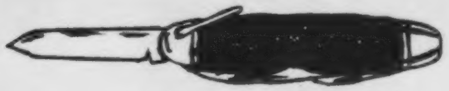

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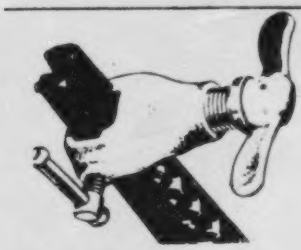

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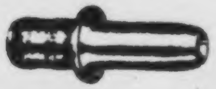

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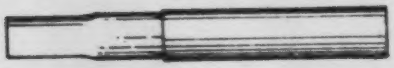

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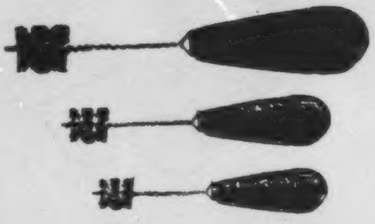

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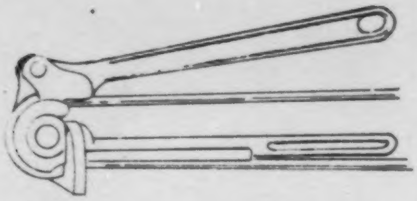

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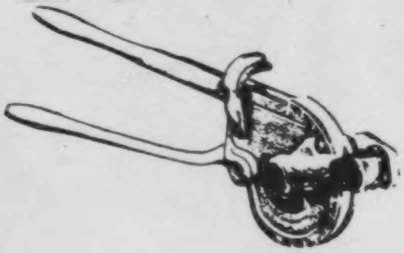

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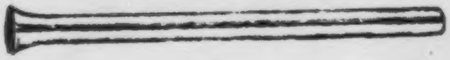

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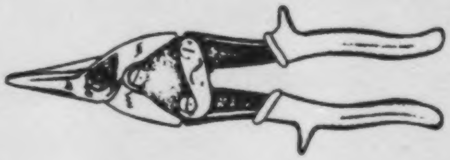

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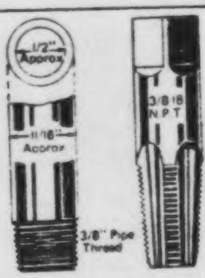

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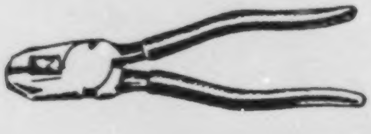

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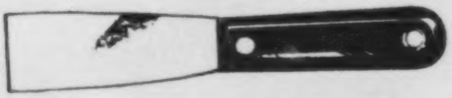

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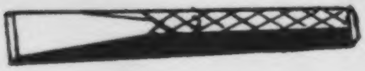

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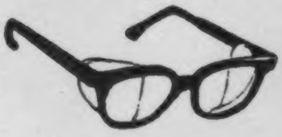

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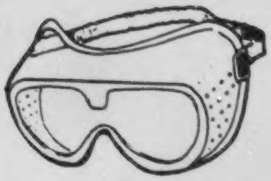

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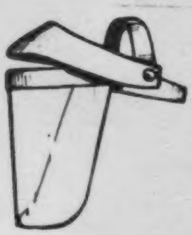

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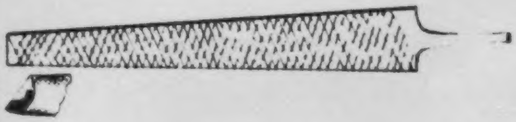

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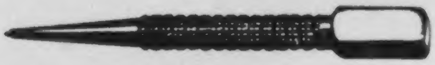

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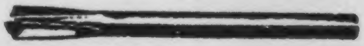

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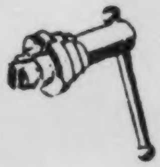


sss. ______________________

3. Select true statements about the use and care of tools usually found in a technician's tool box by placing an "X" in the appropriate blanks.

   _____a. Saw blade should be kept dry and lightly oiled

   _____b. Number of teeth per inch (point) indicate how fine a cut the saw will make _____c. Filing should be done in a "rocking" motion

_____d. Always use a handle on a file

_____e. Folding rules should have a small amount of fine oil applied to the joints in order to lessen wear

_____f. Steel tapes should be rewound with great speed

_____g. Occasionally run a flat file over the surface of a metal level to remove burrs

_____h. Levels can be adjusted to determine correct pitch of drainage pipes

_____i. Plumb bobs are used to locate the center of vertical runs and transfer the point from one floor level to another

_____j. The point on a plumb bob should be rounded or bent

_____k. A chalk line should use only white chalk

_____l. Chalk lines must be kept dry

_____m. Chisels and hammers should be held loosely but firmly in order to "bounce" the chisel as it is struck

_____n. Wood chisels are ground to a 90° angle and must be periodically honed and oiled in order to maintain a sharp edge

_____o. Hand drilling machines are useful for small jobs when electricity is unavailable

_____p. High speed steel drills are useful in cleaning and enlarging holes in metal and other materials, and also for drilling new holes

_____q. Offset wrenches are handy for small pipe and round objects, especially in tight places

_____r. Open-end wrenches are useful because they are not likely to slip off an object when being used

_____s. Needlenose pliers are useful in turning difficult to open locknuts

_____t. Nail pullers are useful when removing studs _____u. Strikers should be kept dry, clean, and free from oil

_____v. A pocket knife is used for reaming large size copper tube and plastic pipe

_____w. Swaging tools are used to make tubing ends smaller

_____x. Goggles protect the whole face from flying chips and splashed liquids

4. List three safety precautions applied to the use of tools usually found in a technician's tool box; list three items under each area.

   a. Condition of tools

      1)

      2)

      3)

   b. Work area

      1)

      2)

      3)

   c. Handling tools

      1)

      2)

      3)

   d. Storing tools

      1)

      2)

      3)

SOLAR TECHNICIAN'S TOOL BOX
UNIT II

ANSWERS TO TEST

1. a. 3
   b. 1
   c. 2
   d. 4
2. a. Hacksaw
   b. Jabsaw
   c. Compass or keyhole saw
   d. Handsaw
   e. Miter saw
   f. Flat file
   g. Round file
   h. Triangular file
   i. Folding rule
   j. Tape measure
   k. 24" carpenter's level
   l. Torpedo level
   m. Plumb bob and line
   n. Chalk line
   o. Set of cold chisels
   p. Set of wood chisels
   q. Nail set
   r. Set of pin punches

s. Hand drilling machine

t. Ratchet brace

u. Set of small masonry drills

v. Set of small high speed drills

w. Set of wood bits

x. Expansive wood bit

y. Straight pipe wrench

z. 14" offset pipe wrench

aa. 8" adjustable wrench

bb. Set of open end wrenches

cc. 8" plier wrench (vise grips)

dd. Set of flare nut wrenches

ee. Set of socket wrenches and ratchet

ff. Internal cutter

gg. Needlenose pliers

hh. 14" adjustable pliers

ii. 10" adjustable pliers

jj. Combination slip-joint pliers

kk. 20 oz. straight claw hammer

ll. 16 oz. ball peen hammer

mm. Nail puller (cats-paw)

nn. Sledge hammer

oo. Set of phillips head screwdrivers

pp. Set of straight tip screwdrivers

qq. Offset screwdriver

rr. Small diameter tubing cutter (1/8" - 1") ss. Small quick opening tubing cutter (1/4" - 1 1/8")

tt. Large tubing cutter (1/4" - 3 1/8")

uu. Close tubing cutter (1/2", 3/4")

vv. Striker

ww. Flux brush

xx. Clean towel

yy. Sandcloth

zz. Pocket knife

aaa. Yoke and screw flaring tool

bbb. Hammer flaring tool

ccc. Swaging tool

ddd. Set of copper fitting brushes

eee. Lever type tubing bender

fff. Geared ratchet type tubing bender

ggg. Spring bender

hhh. Pair of straight snips

iii. Pipe taps (1/8" - 1")

jjj. Dykes (lineman's pliers)

kkk. Putty knife

lll. Cold chisel

mmm. Safety glasses

nnn. Goggles

ooo. Face shield

ppp. Rasp

qqq. Center punch

rrr. Star drill

sss. Internal wrench

3. a,b, d, e, g, h, i, l, m, o, p, r, u, v, w, x

4. Any three under each area:

   a. Condition of tools

      1. Tools should be kept clean
      2. Tools should be free of grease and excess oil
      3. Tools which can rust should be lightly oiled
      4. Keep handles on files
      5. Keep chisel ends trimmed and dressed
      6. Drop cords and extension cords should be in good repair
      7. Cutting tools should be kept sharp in order to prevent forcing or causing the worker to become impatient
      8. Do not use a weak or damaged ladder

   b. Work area

      1. Keep work area clean
      2. Carry to the work area only those tools that you will need
      3. Lay out your tools in an orderly fashion
      4. Provide ample room to work; do not struggle around objects which can be moved
      5. Keep such items as gas hoses and electric cords neat and orderly and not in a tangled mess

   c. Handling tools

      1. Keep tools in their proper places
      2. Sharp instruments such as screwdrivers should not protrude from pockets
      3. Tools should be handed to one another, not thrown or tossed
      4. Electric cords should be kept out of water

   5. Gloves should be worn as a protection against heat and flying chips
   6. Eye and face protection should be used when working with certain tools
   7. Hands should be washed after handling tools and before eating

d. Storing tools

   1. Tools should be stored properly in order to provide ease and safety in picking up and putting away
   2. Heavy tools should be stored near the floor, light tools in higher positions
   3. Attempt to store all tools off the floor to avoid dangerous floor space
   4. Large tools and heavy tool boxes should be moved by two or more people

SPECIAL TOOLS
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify and use the specialized tools used in the solar hot water systems trade. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with specialized tools to the correct definitions.
2. Identify specialized tools.
3. Describe the use of the specialized tools.
4. Demonstrate the ability to sharpen a twist drill bit.

SPECIAL TOOLS
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedure outlined in the job sheet.

   G. Show students special tools.

   H. Take field trip to a parts wholesaler.

   I. Have students look up tools in catalogs to get an idea of the cost involved in equipping a shop.

   J. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheet.

   D. Complete activities assigned by instructor.

   E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

        1. TM 1--Special Tools
        2. TM 2--Special Tools (Continued)
        3. TM 3--Special Tools (Continued)
    D. Job Sheet #1--Sharpen a Twist Drill Bit
    E. Test
    F. Answers to test

II. Reference:

Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. Modern Refrigeration and Air Conditioning. Homewood, Illinois: Goodheart-Willcox Co., 1975.

SPECIAL TOOLS
UNIT III

INFORMATION SHEET

I. Terms and definitions

   A. Conduit--Tubular enclosure for electrical conductors

   B. Thermal electric lead--Lead made up of two dissimilar metals which creates a small amount of voltage upon temperature change

   C. Hygrometer--Humidity sensing device

II. Specialized tools (Transparency 1)

   A. Drill motors

      1. Straight

      2. Offset

   B. Knock-out cutter (Transparency 1)

   C. Riveter (Transparency 1)

   D. Drill bits (Transparency 2)

      1. Twist

      2. Wood

      3. Masonry

   E. Bench grinders (Transparency 2)

   F. Vises

      1. Bench

      2. Pipe

   G. Appliance truck (Transparency 2)

   H. Thermometers (Transparency 3)

      1. Pocket

      2. Remote Bulb

      3. Thermal Electric

I. Recording thermometers (Transparency 3)

1. Manual wind

2. Electric

III. Use of specialized tools

A. Drill motors

1. Straight--For drilling holes in metal or wood

2. Offset--For drilling holes in metal or wood in limited working space

B. Knock-out cutter--For making holes in sheet metal

(NOTE: This cutter is primarily used for making holes in cabinets for electrical conduit and water lines.)

C. Riveter--For riveting pieces of sheet metal together

D. Drill bits

1. Twist--For drilling metal

2. Wood--For drilling wood

3. Masonry--For drilling concrete and stone

E. Bench grinders--For grinding metal edges

F. Vises

1. Bench--For holding objects secure

Example: An object would need to be held secure while it was being drilled, filed, sawed, or electrically tested

2. Pipe--For holding pipe or conduit secure

Example: Pipe or conduit would need to be held secure when it is being cut, threaded, or reamed

G. Appliance truck--For moving water heaters and other heavy equipment

H. Thermometers

1. Pocket--For checking temperature of water at use points.

2. Remote bulb--For checking temperatures in one area and reading the temperature on a dial in another area

3. Thermal electric--For measuring temperatures from -50°F to as high as +1000°F

   (NOTE: This temperature indicating meter is generally capable of checking more than one temperature through the use of multiple leads and by changing the function switch.)

I. Recording thermometers

1. Manual wind--Records temperatures on a time chart

   (NOTE: This recorder can be equipped with a remote temperature sensing bulb, and it has a manual wind clock assembly for advancing the time chart.)

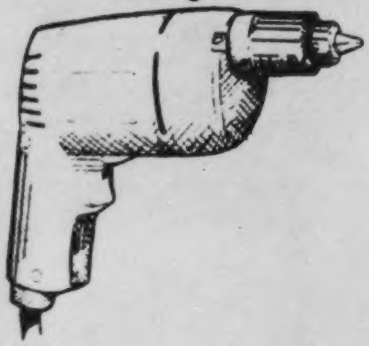
2. Electric--Records temperatures on a strip chart

   (NOTE: This recorder uses thermocouple type leads and will generally record more than one temperature.)

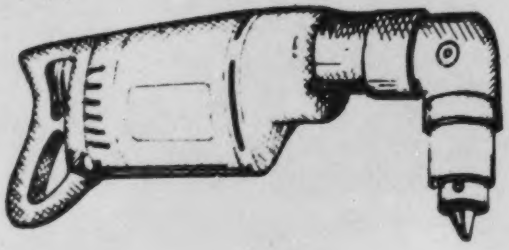
Special Tools

Drill Motors

Straight

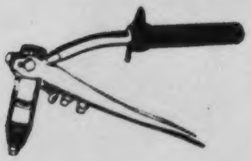


Offset



Knock-Out Cutter

Riveter



Special Tools

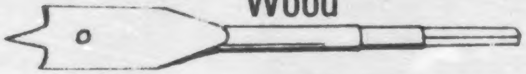
(Continued)

Drill Bits

Twist

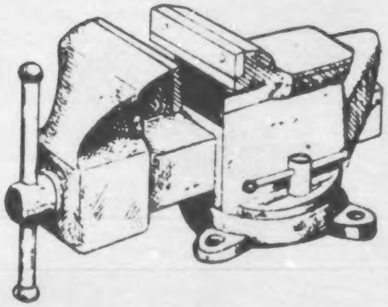
Masonry

Wood



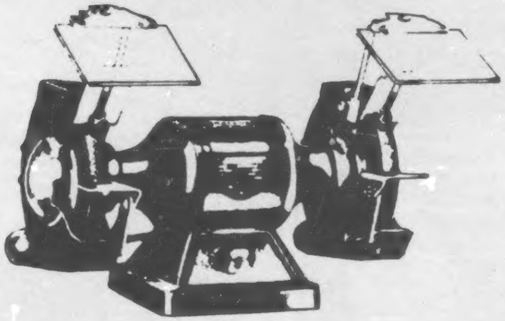
Vises

Bench

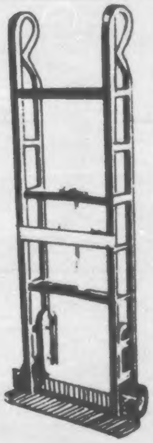


Pipe

Bench Grinder



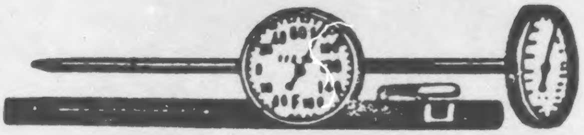
Appliance Truck



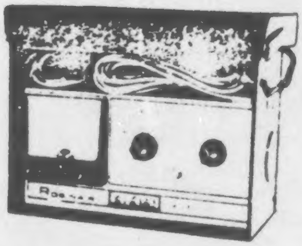
Special Tools

Thermometers

Pocket



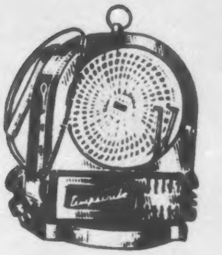
Remote Bulb



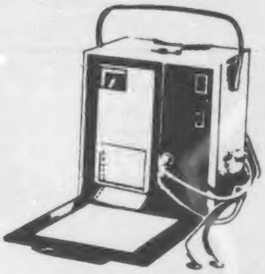
Thermal Electric

Recording Thermometers

Manual Wind



Electric



SPECIAL TOOLS
UNIT III

JOB SHEET #1--SHARPEN A TWIST DRILL BIT

I. Tools and materials

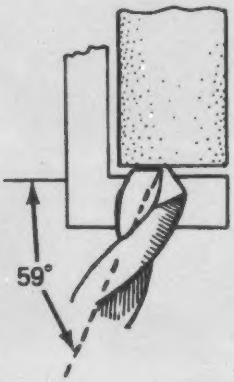
- A. Drill bit
- B. Bench grinder
- C. Water tray
- D. Safety glasses
- E. Drill bit gauge
- F. Oil stone

II. Procedure

- A. Put on safety glasses
- B. Adjust tool rest to proper clearance

  (NOTE: Proper clearance is approximately one-eighth inch from wheel.)
- C. Turn on grinder
- D. Grind each lip of the drill bit to proper angle of 59° (Figure 1)

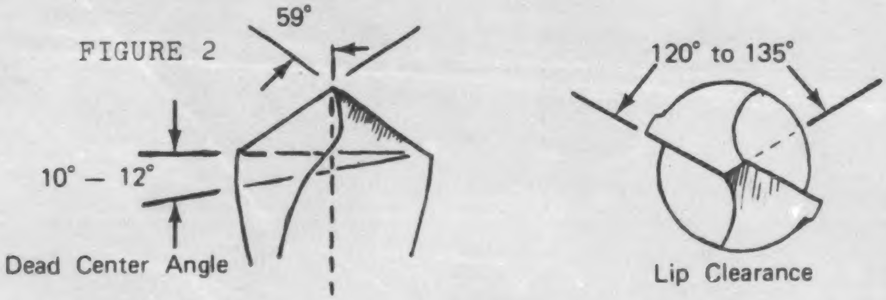
FIGURE 1



Grinding the Drill

E. Roll drill bit to the right and up to the face of the stone to generate back clearance angle of 10° to 12° (Figure 2)

FIGURE 2



Dead Center Angle

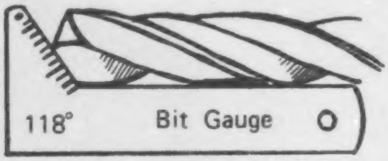
Lip Clearance

F. Dip in water tray occasionally to prevent overheating the drill bit

G. Check correct angle with a bit gauge (Figure 3)

FIGURE 3

Check Angle



H. Turn off grinder

I. Hone cutting edges of the drill bit to remove burrs

J. Recheck all cutting angles

SPECIAL TOOLS
UNIT III

NAME__________________________

TEST

1. Match the terms on the right to the correct definitions.

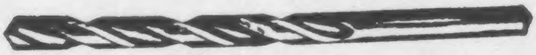
_____a. Tubular enclosure for electrical conductors

_____b. Lead made up of two dissimilar metals which creates a small amount of voltage upon temperature change

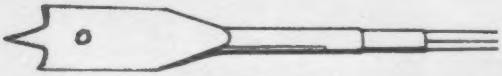
1. Conduit

2. Thermal electric lead

2. Identify specialized tools.



a. __________________________



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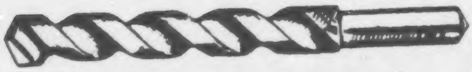
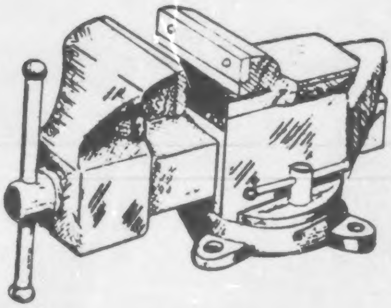
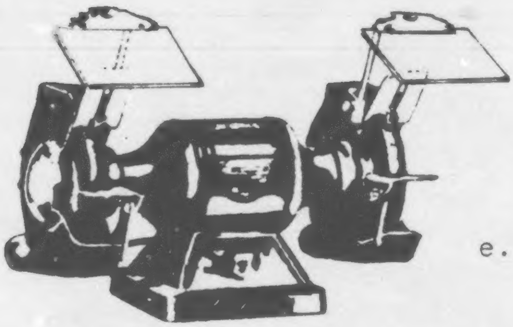


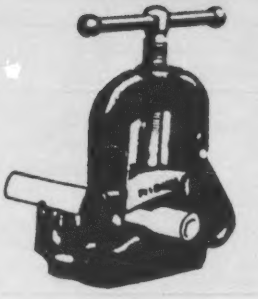
c. __________________________



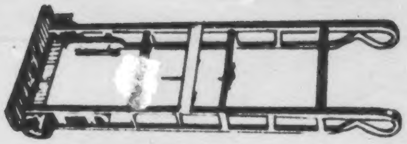
e. __________________________



d. __________________________



f. ______________________



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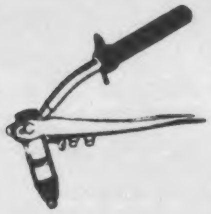

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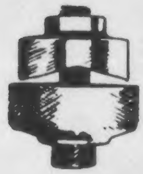

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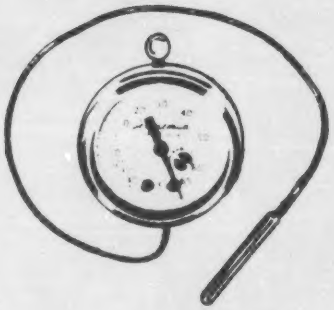

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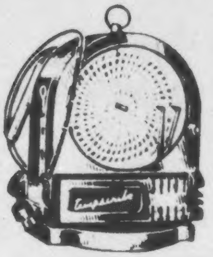

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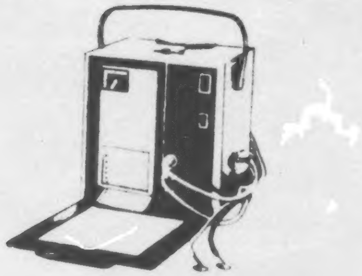
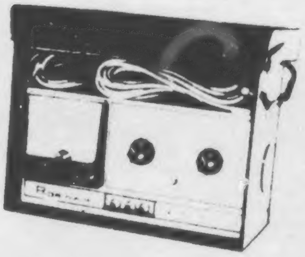


l. ______________________



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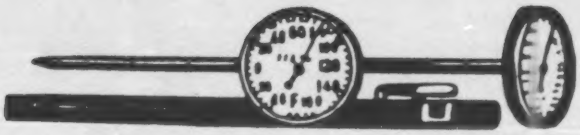
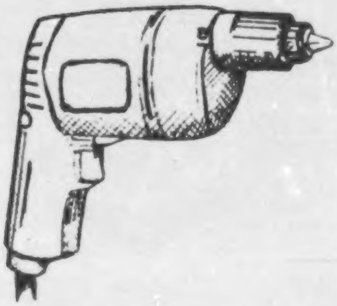
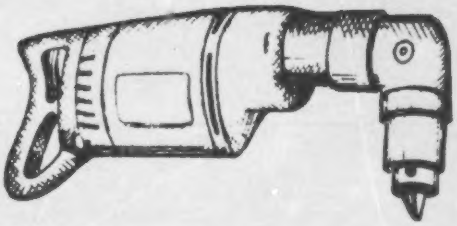


n. ______________________________





o. ______________________________

p. ______________________________

3. Describe the use of specialized tools.

a. Thermometers

1) Thermal electric ____________________

2) Pocket ____________________

3) Remote bulb ____________________

b. Vises

1) Pipe ____________________

2) Bench ____________________

c. Drill motors

1) Straight ____________________

2) Offset ____________________

d. Recording thermometers

1) Manual wind ____________________

2) Electric ____________________

e. Bench grinders ____________________

f. Drill bits

1) Twist ____________________

2) Wood______________________________

3) Masonry______________________________

____

g. Knock-out cutter______________________________

____

h. Riveter______________________________

i. Appliance truck______________________________

____

4. Demonstrate the ability to:

a. Sharpen a twist drill bit

(NOTE: If this activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

SPECIAL TOOLS
UNIT III

ANSWERS TO TEST

1. a. 1
   b. 2
2. a. Twist drill bit
   b. Wood drill bit
   c. Masonry drill bit
   d. Bench grinder
   e. Bench vise
   f. Pipe vise
   g. Hand trucks
   h. Riveter
   i. Knock-out cutter
   j. Recording thermometer-electric
   k. Thermometer-remote bulb
   l. Recording thermometer-manual
   m. Thermometer-thermal electric
   n. Thermometer-pocket
   o. Drill motor-straight
   p. Drill motor-offset
3. Description should include:
   a. Thermometers
      1. Thermal electric--For measuring temperatures from -50° to as high as +1000°F
      2. Pocket--For checking temperature of water at faucett

        3. Remote bulb--For checking temperatures in one area and reading the temperature on a dial in another area

    b. Vises

        1. Pipe--For holding pipe or conduit secure

        2. Bench--For holding objects secure

    c. Drill motors

        1. Straight--For drilling holes in metal or wood

        2. Offset--For drilling holes in metal or wood in limited working space

    d. Recording thermometers

        1. Manual wind--Records temperatures on a time chart

        2. Electric--Records temperatures on a strip chart

    e. Bench grinders--For grinding metal edges

    f. Drill bits

        1. Twist--For drilling metal

        2. Wood--For drilling wood

        3. Masonry--For drilling concrete and stone

    g. Knock-out cutter--For making holes in sheet metal

    h. Riveter--For riveting pieces of sheet metal together

    i. Appliance truck--For moving refrigerators and other heavy equipment

4. Evaluated to the satisfaction of the instructor.

POWER TOOLS
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify power tools used by solar hotwater system installer. The student should also be able to discuss the use of these tools and list safety precautions to be taken when using them. This knowledge will be evidenced by correctly performing the procedures outlined on the job sheets and scoring 85 percent on the unit test.

(NOTE: The student must score 100% on the safety section of the test.)

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Define terms associated with power tools and their use.
2. Identify power tools generally used in assembling and installing solar hotwater systems.
3. List two statements associated with the proper use and care of power tools.
4. List ten safety precautions to be applied in the use of power tools used to assemble and install solar systems.
5. Demonstrate the ability to:
    a. Make 45° angle cuts in aluminum angle using a bench band saw.
    b. Install an angle bracket on a concrete block with plastic anchors.
    c. Drill a round hole in aluminum angle using a round hole saw and mandrel.

POWER TOOLS
UNIT IV

SUGGESTED ACTIVITIES

I. Instructor

  A. Provide student with objective sheet.

  B. Provide student with information and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Conduct a tour of the shop and identify equipment.

  F. Invite a manufacturer's representative to address the class.

  G. Conduct a demonstration of drilling holes through wood and metal.

  H. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete job sheets.

  D. Take test

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Drilling Machines

    2. TM 2--Saws

    3. TM 3--Concrete Tools

D. Job sheets

  1. Make 45° angle cuts in aluminum angle using a bench band saw

  2. Install an aluminum angle bracket on a concrete block with plastic anchors

  3. Drill a 3/4" round hole in aluminum angle using a round hole saw and mandrel

E. Test

F. Answers to test

II. References:

A. Blankenbaker. E. Keith. Modern Plumbing. South Holland, Ill: Goodheart-Willcox Co., Inc., 1978.

B. Bureau of Naval Personnel. Tools and Their Uses. Washington, D.C.: U.S. Government Printing Office, 1971.

C. Jacobs, Clinton O., and J. Howard Turner. Developing Shop Safety Skills. Athens, Ga.: American Assn. for Vocational Instructional Materials, 1979.

POWER TOOLS
UNIT IV

INFORMATION SHEET

I. Terms and definitions

  A. Power tools--Tools operated with electricity, air, or gasoline

  B. Hand tools--Tools which are hand held and are not operated by electricity, air, or gasoline

  C. Roughing-in tools--Tools both hand and power, used to install the initial stage of the solar system, including cutting and drilling access holes, and connecting piping

  D. Reciprocating--Moving in a back and forth motion, as opposed to a circular motion

  E. Abrasive--Cutting and grinding of material by a thin wheel made of a hard stone-like substance

II. Power tools generally used in assembling and installing solar hotwater systems.

  A. Drilling machines (Transparency 1)

  (NOTE: These are often referred to as drills. The sizes of drilling machines are classified by the maximum size straight shank drill they will hold.)

    1. Electric drill - 1/4"

    2. Electric drill - 1/2"

      a. Straight

      b. Angle

    3. Assortment of wood bits

    4. Extension

  B. Saws (Transparency 2)

    1. Portable electric saw

    2. Hole saw

    3. Bench band saw

      4. Circular saw

      5. Band saw (portable)

      6. Sabre saw

   C. Concrete tools (Transparency 3)

      1. 3/8" hammer drill

III. Use and care of power tools

   A. Drilling machines

      1. Small drills (1/4") develop more R.P.M.'s than large drills because the larger units are designed to turn larger cutting tools or to drill in heavy materials, and both of these require a slower speed

      2. The chuck key should be strapped to the power cord

         (NOTE: Loss of the chuck key promotes short tempers, poorly improvised substitutes for the key, and poor drilling jobs.)

      3. The cutting tool must be kept sharp in order to avoid forcing the machine and causing unnecessary wear and short life

         (NOTE: Before cutting out for pipe, make sure all nails have been pulled from the area.)

      4. Drilling machines should be kept in the storage box when not in use in order to avoid damage

   B. Saws

      1. Saw blades should be kept sharp in order to avoid excessive forcing of the machine

      2. Portable electric circular saws are used for cutting lumber, but can be fitted with abrasive wheels to cut metal and concrete

      3. Power saws should be operated at a limited speed of cut in order to avoid blade breakage

      4. Reciprocating power saws are often used for cutting irregular shaped pipe holes and openings, especially in difficult to-get-at places

      5. Small reciprocating power saws (saber saws) are helpful in cutting out-holes for pipe lines

6. Hole saws cut holes in wood or metal

C. Concrete tools

1. Used for cutting into and through concrete

2. Hammer drills make holes in concrete by "hammering" the rotating bit

IV. Safety precautions

A. Know the tool you are using, its application, limitations, and potential hazards

B. Select proper tool for the job

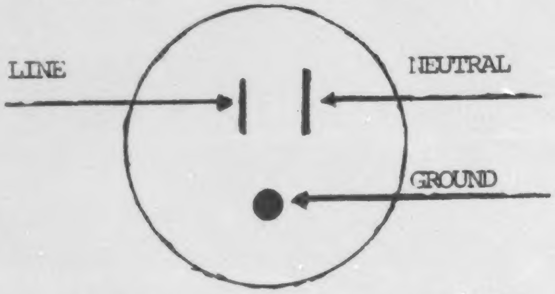
1. Don't try to tackle a big job with an undersized tool

2. Makeshift tools can cause accidents

C. Ground all tools unless double insulated

1. Three-prong plug should be plugged into a three-hole electrical receptacle (Figure 1)

FIGURE 1



2. If adapter is used to accomodate two-prong receptacle, the adapter wire must be attached to a known ground

(CAUTION: Never remove the ground plug from your cord.)

D. Remove adjusting keys and wrenches before turning on tool

E. Keep work area free of clutter

(NOTE: Boards, boxes, debris, and tools, can be tripping hazards.)

F. Keep guards in place and in working order

1. Do not remove
2. Do not wedge out of the way

G. Always be alert to potential hazards in your working environment

1. Be very cautious of damp locations when working with electricity
2. Be aware of the presence of highly combustible materials such as gasoline and naptha

H. Avoid accidental startup

1. Make sure switch is off before plugging in cord
2. Turn power switch off when power is interrupted

   (NOTE: Don't carry plugged in tool with finger on switch.)

I. Make sure saw blades, drill bits, and cutters are sharp, clean, and regularly maintained

J. Use only accessories recommended by the manufacturer

K. Do not force tool

(NOTE: It will do a better and safer job at its designed speed.)

L. Wear safety glasses

(NOTE: Also use face or dust mask if operation requires it.)

M. Do not overreach

(NOTE: Keep proper footing and balance at all times.)

N. Never leave tool running unattended

1. Don't leave until it comes to a complete stop
2. Don't leave until it is disconnected from power source
3. Don't remove drill or bit until machine has stopped running

O. Don't surprise or touch anyone operating a power tool

(NOTE: The distraction could cause a serious accident.)

P. Never adjust, change bits, blades, or cutters with tool connected to power

Q. Dress properly

1. Avoid loose clothing that could catch in moving parts

2. Wear rubber boots in wet locations

3. Gloves can be caught by revolving machinery

R. Secure work

(NOTE: Using clamps or vise to hold work when practical frees both hands to operate tool.)

S. Do not use tool with frayed cord

(NOTE: Return frayed cords for servicing. Use only heavy duty U.L. listed extension cords of proper wire size and length.)

T. Never brush away chips or sawdust while tool is operating

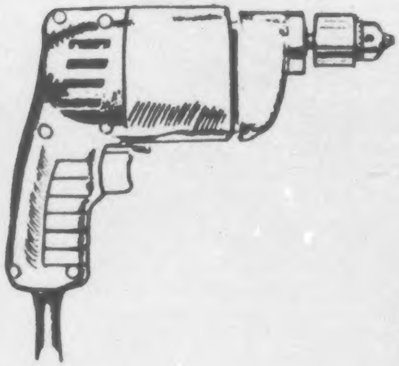
U. Do not attempt field repairs

(NOTE: Return for servicing any tool that shows slightest defect or is not operating properly.)

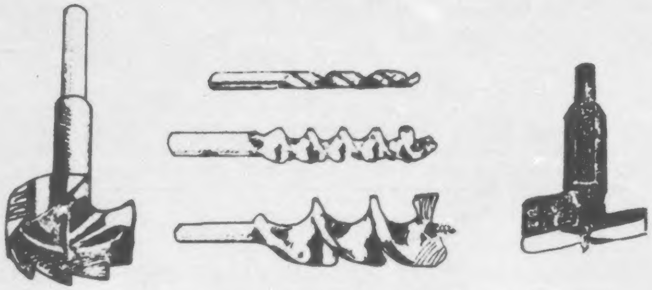
V. Store tools in dry, secure location where they won't be tampered with or stolen

Drilling Machines

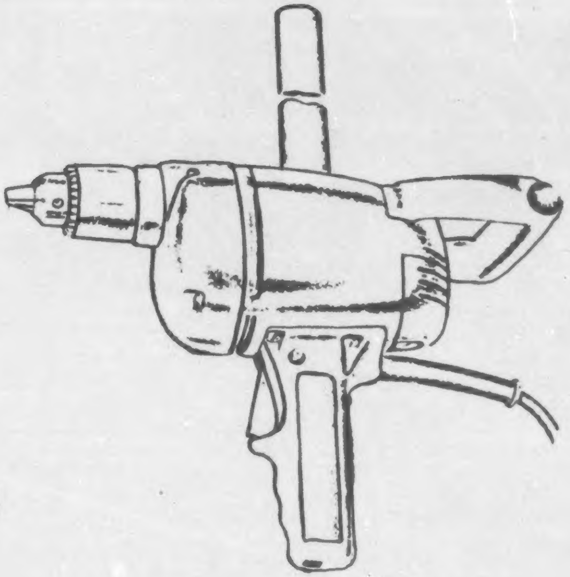
¼" Electric Drill



Extension

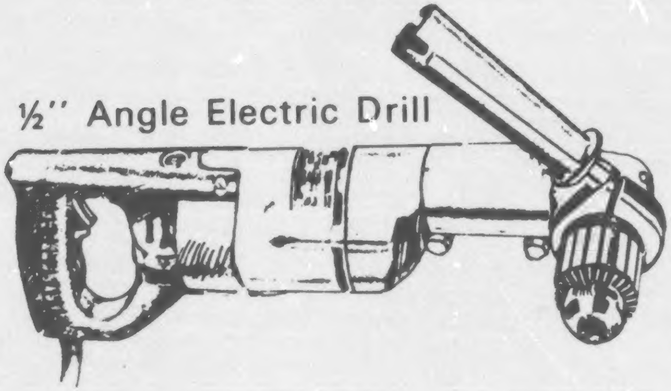


Assortment Of Wood Bits



½" Straight Drill

½" Angle Electric Drill

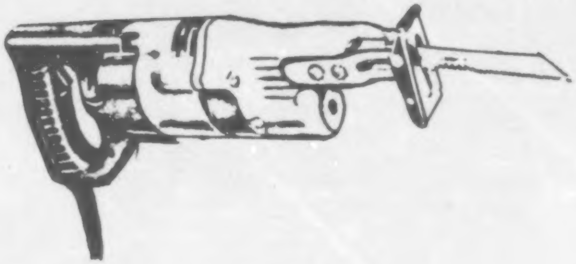


Illustrations of 1/4" electric drill, 1/2" angle electric drill, and assortment of wood bits courtesy of Milwaukee Tool Company.

Illustration of 1/2" straight electric drill courtesy of Stanley Tool Company.

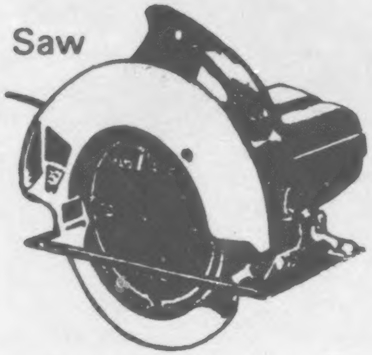
Saws

Portable Electric Saw

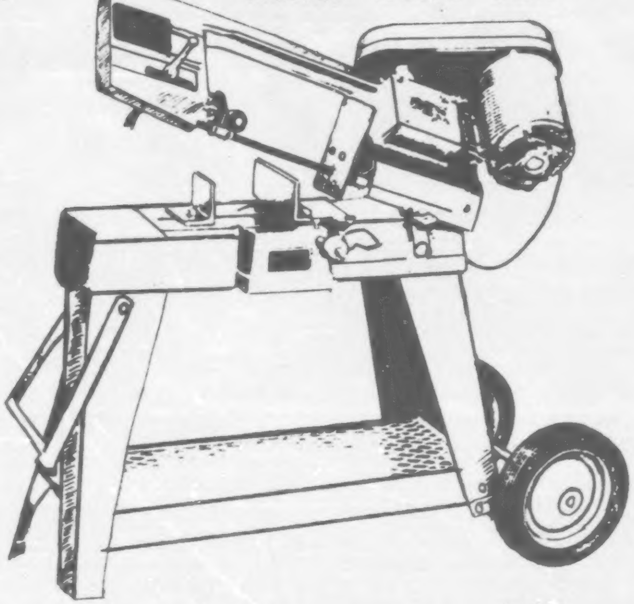


Hole Saw

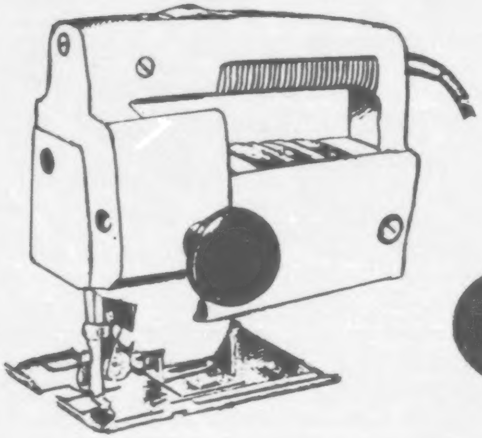
Circular Saw



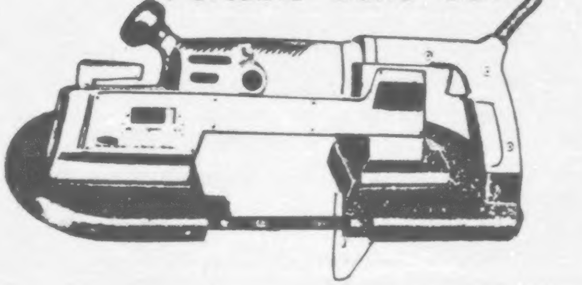
Bench Band Saw



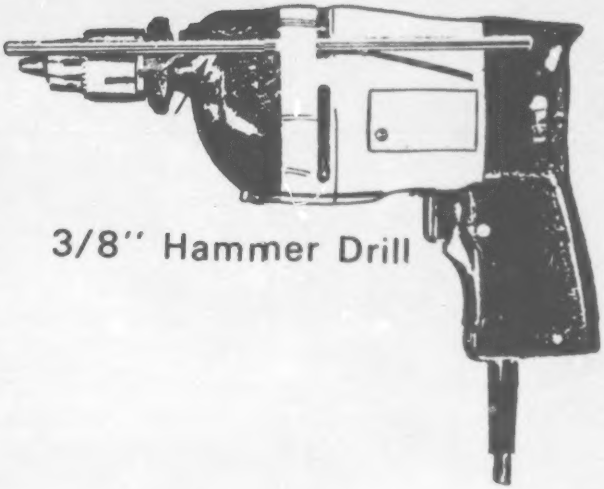
Sabre Saw



Portable Band Saw



Concrete Tools



3/8" Hammer Drill

POWER TOOLS
UNIT IV

JOB SHEET #1--MAKE 45° CUTS IN ALUMINUM ANGLE USING A BENCH BAND SAW

EVALUATION: Given access to tools, equipment and material, make 45° angle cuts in 3/16" aluminum angle using a bench band saw. Evaluation will include use of correct safety procedures, correct use of equipment, and accuracy of cuts.

I. Tools, equipment and materials

- A. Bench band saw
- B. Protractor
- C. Four foot length of 3/16" x 2 1/2" x 2 1/2" aluminum angle
- D. Safety glasses

II. Procedures

- A. Check band saw for correct blade
- B. Check condition of band saw guards and clamps
- C. Using the protractor mark off two 45° lines at six inch intervals
- D. Secure aluminum angle in saw rack for first cut
- E. Put on safety glasses
- F. Turn on saw and complete first cut
- G. Adjust aluminum angle for second cut
- H. Complete second cut
- I. Have the instructor check your work
- J. Clean up area
- K. Return unused angle to stock
- L. Put away tools and equipment

POWER TOOLS
UNIT IV

JOB SHEET #2--INSTALL AN ALUMINUM ANGLE-BRACKET ON A CONCRETE BLOCK WITH PLASTIC ANCHORS

EVALUATION: Given access to tools and materials install an aluminum angle bracket on a concrete block. Evaluation will include use of correct safety procedures, correct use of tools and work manship.

I. Tools and materials

- A. Safety goggles
- B. 3/8" hammer drill
- C. Six inch piece of 2 1/2" x 2 1/2" x 3/16" aluminum angle with pre-drilled holes
- D. Two 1/4" plastic anchors
- E. Two #12 sheet metal screws
- F. One 1/4" masonary drill bit
- G. One concrete block

II. Procedures

- A. Mark holes to be drilled with bracket in the horizontal position on the block
- B. Adjust depth bar for length of screw
- C. Secure masonary bit in drill
- D. Put on safety goggles
- E. Drill two holes at selected spots on block
- F. Insert plastic anchors
- G. Install bracket using the two #12 screws
- H. Have the instructor evaluate your work
- I. Remove the bracket
- J. Clean up area and put away tools and materials

POWER TOOLS
UNIT IV

JOB SHEET #3--DRILL A ROUND HOLE IN ALUMINUM ANGLE USING A ROUND HOLE SAW AND MANDREL

EVALUATION: Given access to tools and materials, drill a 3/4" round hole in a 12" length of aluminum angle using a 1/2" straight drill. Evaluation will include use of correct safety procedures, correct use of tools, and workmanship.

I. Tools and materials

   A. 1/2" straight drill with chuck key

   B. One 3/4" round hole metal saw

   C. One mandrel

   D. One 12" piece of selected aluminum angle

   E. One center punch

   F. Safety glasses

II. Procedures

   A. Mount the piece of angle in a bench vise

   B. Mark the area to be drilled

   C. Center punch the center of mark

   D. Install mandrel and hole saw in drill

   E. Put on safety glasses

   F. Using light pressure on drill, drill the hole

   G. Have the instructor evaluate your work

   H. Clean up area and put away tools and material

POWER TOOLS
UNIT IV

NAME______________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Tools operated with electricity, air, or gasoline

_____b. Tools which are hand held and are not operated by electricity, air, or gasoline

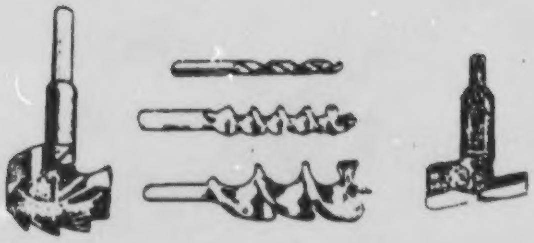
_____c. Tools, both hand and power, used to install the initial stage of the solar's system including cutting and drilling access holes, and connecting piping

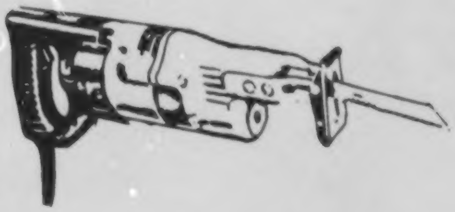
_____d. Moving in a back and forth motion, as opposed to a circular motion

_____e. Cutting and grinding of material by a thin wheel made of a hard stone-like substance

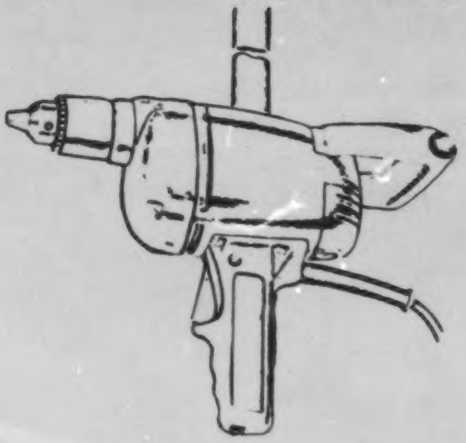
1. Hand tools
2. Reciprocating
3. Power tools
4. Abrasive
5. Roughing-in tools

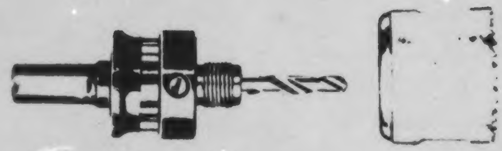
2. Identify power tools generally used to install solar hotwater systems





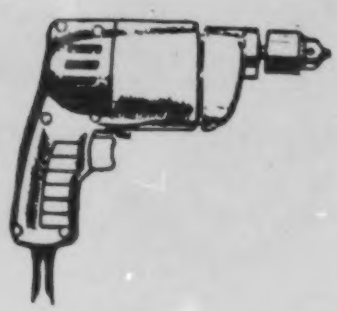
a. ______________________________ b. ______________________________

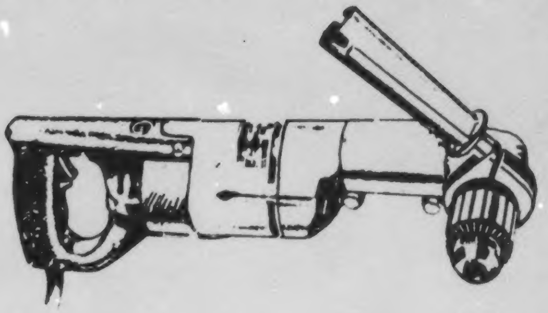




c. ____________________

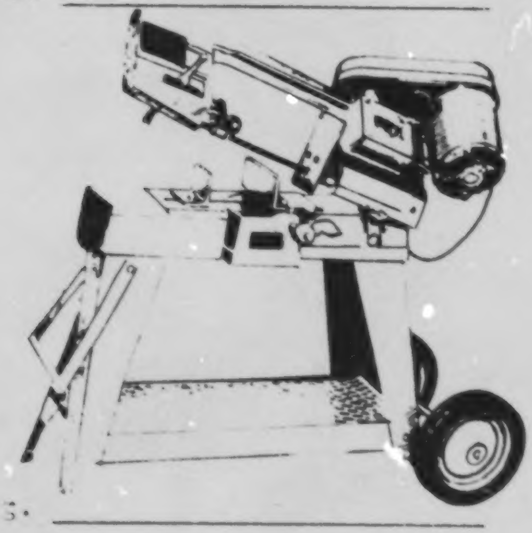
d. ____________________

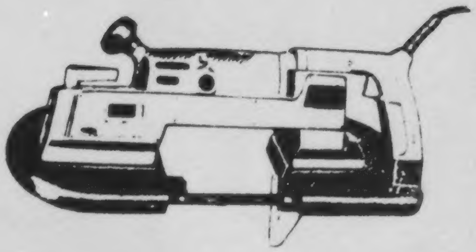




e. ____________________

f. ____________________

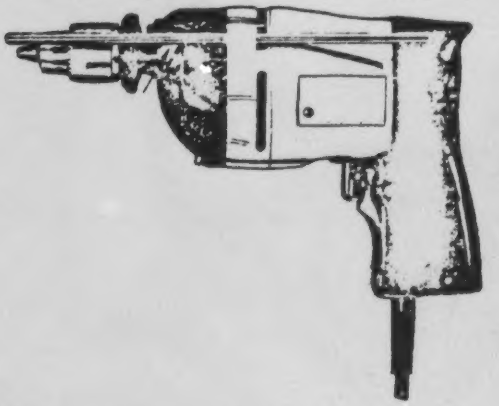




h. ____________________

g. ____________________

i. ____________________



j. ____________________

3. List two statements associated with the proper use and care for each of the following power tools.

   a. Drilling machines

      1. ____

      ____

      2. ____

      ____

   b. Saws

      1. ____

      ____

      2. ____

      ____

   c. Concrete tools

      1. ____

      ____

      2. ____

      ____

4. List 10 safety precautions to be applied in the use of power tools used in the installation of solar hotwater systems.

   a. ____
   b. ____
   c. ____
   d. ____
   e. ____
   f. ____
   g. ____
   h. ____

i. ______________________________

j. ______________________________

5. Demonstrate the ability to:

   a. Make 45° angle cuts in aluminum angle using a bench band saw

   b. Install an angle bracket on a concrete block

   c. Drill a round hole in aluminum angle using a round hole saw and mandrel

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

POWER TOOLS
UNIT IV

ANSWERS TO TEST

1. a. 3
   b. 1
   c. 5
   d. 2
   e. 4

2. a. Assortment of wood bits
   b. Portable electric saw
   c. 1/2" straight electric drill
   d. Hole saw
   e. 1/4" electric drill
   f. 1/2" angle drill
   g. Band saw
   h. Portable band saw
   i. Extension
   j. 3/8" hammer drill

3. Any two of the following statements under each of the power tools:

   a. Drilling machines

      1. Small drills (1/4") develop more R.P.M.'s than large drills because the larger units are designed to turn larger cutting tools or to drill in heavy materials, and both of these require a slower speed

      2. The chuck key should be strapped to the power cord

3. The cutting tool must be kept sharp in order to avoid forcing the machine and causing unnecessary wear and short life

4. Drilling machines should be kept in the storage box when not in use in order to avoid damage

b. Saws

1. Saw blades should be kept sharp in order to avoid excessive forcing of the machine

2. Portable electric circular saws are used for cutting lumber, but can be fitted with abrasive wheels to cut metal and concrete

3. Power saws should be operated at a limited speed of cut in order to avoid blade breakage

4. Reciprocating power saws are often used for cutting irregular shaped pipe holes and openings, especially in difficult to-get-at places

5. Small reciprocating power saws (saber saws) are helpful in cutting out-holes for pipe lines

6. Hole saws cut holes in wood or metal

c. Concrete tools

1. Used for cutting into and through concrete

2. Hammer drills make holes in concrete by "hammering" the rotating bit

4. Any ten of the following:

a. Know the tool you are using, its application, limitations, and potential hazards

b. Select proper tool for the job

1. Don't try to tackle a big job with an undersized tool

2. Makeshift tools can cause accidents

c. Ground all tools unless double insulated

1. Three-prong plug should be plugged into a three-hole electrical receptacle

   2. If adapter is used to accomodate two-prong receptacle, the adapter wire must be attached to a known ground

d. Remove adjusting keys and wrenches before turning on tool

e. Keep work area free of clutter

f. Keep guards in place and in working order

   1. Do not remove

   2. Do not wedge out of the way

g. Always be alert to potential hazards in your working environment

   1. Be very cautious of damp locations when working with electricity

   2. Be aware of the presence of highly combustible materials such as gasoline and a naptha

h. Avoid accidental startup

   1. Make sure switch is off before plugging in cord

   2. Turn power switch off when power is interrupted

i. Make sure saw blades, drill bits, and router cutters are sharp, clean, and regularly maintained

j. Use only accessories recommended by the manufacturer

k. Do not force tool

l. Wear safety glasses

m. Do not overreach

n. Never leave tool running unattended

   1. Don't leave until it comes to a complete stop

   2. Don't leave until it is disconnected from power source

   3. Don't remove drill or bit until machine has stopped running

o. Don't surprise or touch anyone operating a power tool

p. Never adjust, change bits, blades or cutters with tool connected to power

q. Dress properly

  1. Avoid loose clothing that could catch in moving parts

  2. Wear rubber boots in damp locations

  3. Gloves can be caught by revolving machinery

r. Secure work

s. Do not use tool with frayed cord

t. Never brush away chips or sawdust while tool is operating

u. Do not attempt field repairs

v. Store tools in dry, secure location where they won't be tampered with or stolen

5. Performance skills evaluated to the satisfaction of the instructor.

EQUIPMENT
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify the equipment used in the installation of solar hotwater systems. The student should also be able to match correct use and care statements to a specific piece of equipment and list safety rules for operating an air-acetylene torch outfit. This knowledge will be evidenced by correctly performing the procedures outlined on the job sheets and by scoring 85 percent on the unit test.

(NOTE: The student must score 100 percent on the safety scetion of the test.)

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with equipment to correct descriptions and definitions.
2. Identify equipment generally used to install solar hotwater systems.
3. Match types of equipment to the correct use and care statements.
4. Match safety precautions related to operating an air-acetylene torch outfit.
5. Demonstrate the ability to:
    a. Light and adjust the air-acetylene torch.
    b. Grind a flat tip screwdriver.
    c. Grind the head of cold chisel or punch.
    d. Sharpen a cold chisel.

EQUIPMENT
UNIT V

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Arrange for manufacturer's representative to address the class.

   H. Give a safety talk on gas and gas equipment

   I. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Air-Acetylene Torch Outfit

      2. TM 2--Air-Acetylent Torch Outfit (Continued)

3. TM 3--Ladders
4. TM 4--Site Layout and Measuring Tools
5. TM 5--Dolly, Hand Truck, Ropes, and Slings
6. TM 6--Cleaning and Excavating Equipment
7. TM 7--Wrenches
8. TM 8--Pipe Cutting Equipment

D. Job Sheets

1. Job Sheet #1--Light and Adjust the Air-Acetylene Torch
2. Job Sheet #2--Grind a Flat Tip Screwdriver
3. Job Sheet #3--Grind the Head of a Cold Chisel or Punch
4. Job Sheet #4--Sharpen a Cold Chisel

E. Test

F. Answers to test

II. References:

A. Blayton, Joseph W. Plumbing Apprentice Training. Washington, D.C.: Joint Apprentice Test, 1951.

B. Blankenbaker, E. Keith. Modern Plumbing. South Holland, IL: Goodheart-Willcox Co., Inc., 1978.

EQUIPMENT
UNIT V

INFORMATION SHEET

I. Terms and definitions

   A. Propane--A heavy, flammable, gaseous, paraffin hydrocarbon found in crude petroleum and natural gas and used as a fuel

   B. Torch--Tool used to create a controlled flame which is used for soldering copper fittings

   C. Acetylene--A colorless, gaseous hydrocarbon made by the action of water on calcium carbide and used as a fuel

   D. Hoist--Instrument used to lift heavy objects with the least amount of strain on the worker

   E. Bench grinder--Electric powered grinding wheel used to sharpen tools and wear away excess metal from various objects

II. Equipment generally used to install solar systems

   A. Torches

      1. Air-acetylene torch outfit (Transparencies 1 and 2)

         a. Torch handle

         b. Hose

         c. Regulator

         d. High temperature wraparound flame tip

         e. Tips

         f. Striker

         g. "MC" acetylene tank

         h. Cylinder wrench

         i. "B" acetylene tank

B. Ladders (Transparency 3)
    1. Stepladder
    2. Single ladder
    3. Extension ladder

C. Site layout and measuring tools (Transparency 4)
    1. 100' steel tape
    2. Chalk line and reel
    3. Plumb bob

D. Hoists (Transparency 5)
    1. Ropes and slings

E. Dollies and hand trucks (Transparency 5)
    1. Dolly
    2. Hand truck

F. Cleaning equipment (Transparency 6)
    1. Hand broom
    2. Push broom
    3. Bench broom

G. Excavating equipment (Transparency 6)
    1. Sharp shooter
    2. Long handle round point shovel
    3. Long handle square point shovel

       (NOTE: The above listed shovels are made with long and short handles.)

H. Wrenches (Transparency 7)
    1. Light duty chain wrench
    2. Heavy duty chain wrench
    3. 24", 36" straight pipe wrenches

I. Pipe cutting equipment (Transparency 8)

1. Vise stand
2. Pipe reamers
3. Wheel pipe cutter

III. Use and care of equipment

A. Torches (Transparencies 1 and 2)

1. Torches (in residential piping) are used to heat copper tube and melt solder to make sweat joints

2. Torch tips must be handled carefully in order to avoid denting and crimping

   (NOTE: A damaged tip can cause a faulty flame.)

3. Torches must be kept clean

   (NOTE: Molten solder falling onto torch can clog air vents and torch tip.)

4. Proper tools must be used to open gas tanks: a cylinder wrench for acetylene tank

B. Ladders (Transparency 3)

1. The stepladder is used when working short distances above ordinary reach level

2. Single ladders are used to reach the roof of single story buildings

   (NOTE: Legs of single and extension ladders should be secured in order to avoid slipping.)

3. Single ladders are used in new buildings where no staircases have been installed

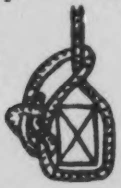
   (CAUTION: Do not use step ladders to reach areas which necessitate standing on the top step of the ladder.)

4. Extension ladders are used to reach the roof of two story buildings

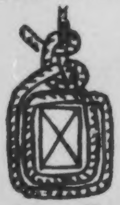
C. Hoists (Transparency 5)

1. Ropes and slings help make lifting easier and help prevent strains and bruises

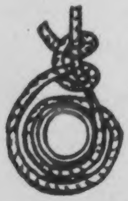
   (NOTE: Use of correct knots prevents slippage and possible accidents.)



Running Bowline



Double Turn And Two Half Hitches Around Beam



Double Turn And Two Half Hitches Around Pipe

D. Dollies and hand trucks (Transparency 5)

   1. Dollies can transport heavy objects along level surfaces and slight grades

   2. Hand trucks can transport heavy objects over rough ground, up and down stairs, up and down steep grades, and over level surfaces

E. Excavating equipment (Transparency 6)

   1. Round pointed shovels are used for general digging purposes

   2. Square pointed shovels are used for cutting straight lines in grass sod, squaring corners of excavations, and helping to make tunnels under sidewalks, shrubs, driveways or porches

   3. Sharp shooter shovels are used to make tunnels under sidewalks, shrubs, driveways, porches, and footings

IV. Safety precautions related to operating an air-acetylene torch outfit

A. Regulator

   1. Keep regulator off when not in use

   2. Be sure to turn adjustment screw completely off prior to start up

      (NOTE: Failure to turn screw off may burst the regulator which may cause injury to the operator.)

3. Inspect all nuts and connections prior to using the regulators
4. Do not force connections of hoses and regulators
5. Use the proper regulator on the proper cylinder
6. Do not exceed recommended pressures
7. Have only skilled mechanics repair faulty regulators

B. Gauges

1. Keep glass protected from breaking
2. Replace any broken gauge glasses
3. Do not attempt to repair a defective gauge

C. Hoses

1. Test hoses for leaks by immersing in water at normal working pressure.

   (NOTE: Leaky hoses should be properly repaired or replaced.)

2. Use only one type of gas in the hose

   (NOTE: A mixture of different gases in the hose could result in an explosion.)

3. Avoid dragging the hose on a greasy floor
4. Avoid circumstances where a hose can be rolled upon, kinked, burned, or subjected to falling objects or hot metals
5. Keep hose connections tight
6. Do not repair a hose with tape
7. Keep the hose properly rolled and stored when not in use

   (NOTE: Spring type hose reels are also available.)

D. Torches

1. Keep all connections to the torch tight

   (NOTE: Test them accordingly.)

2. Any torch suspected of being faulty should be repaired by a competent serviceman

3. Avoid any contact with greasy or oily substances

4. Restrictions in the tip may cause back pressure and leakage

   (NOTE: Handle tips carefully.)

E. Torch tips

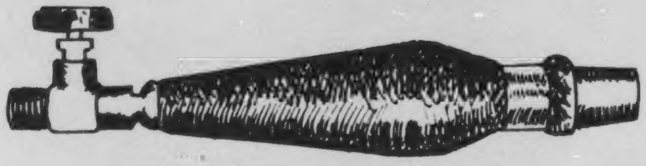
1. Do not remove a tip from the torch when it is hot

   (NOTE: Allow it to cool first.)

2. Use the manufacturer's wrench to remove the torch tip

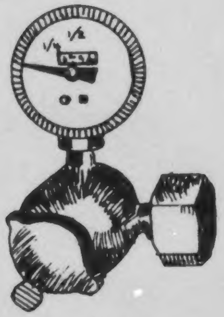
   (NOTE: Do not use pliers.)

Air-Acetylene Torch Outfit



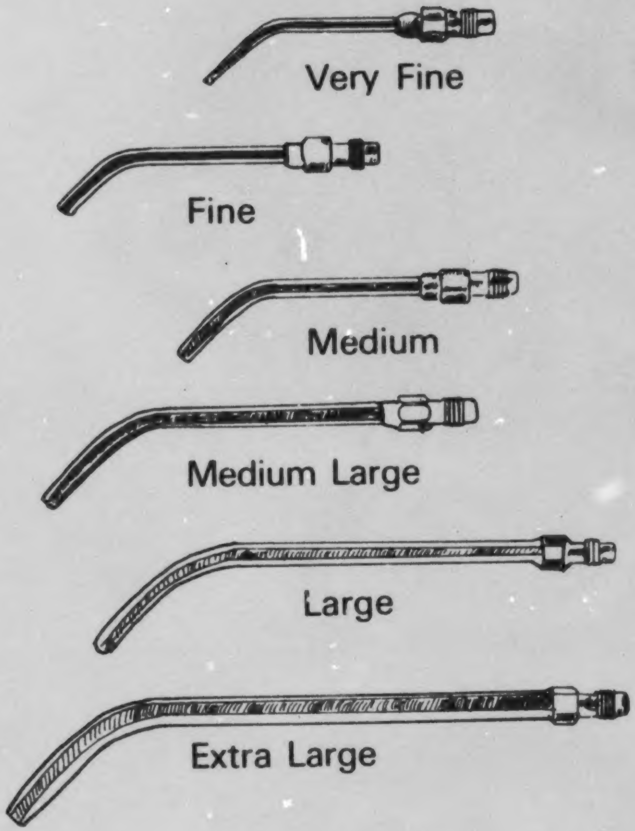
Torch Handle

Hose



Regulator

High Temperature
Wraparound Flame Tip



Very Fine

Fine

Medium

Medium Large

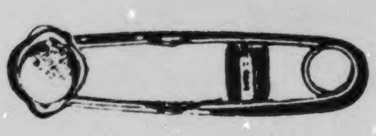
Large

Extra Large

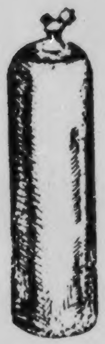
Tips

Air-Acetylene Torch Outfit

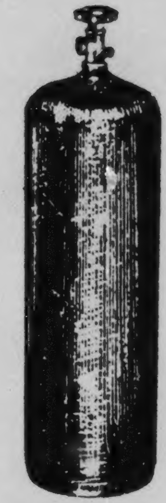
(Continued)



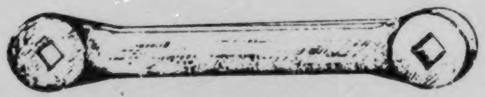
Striker



"MC" Acetylene Tank



"B" Acetylene Tank



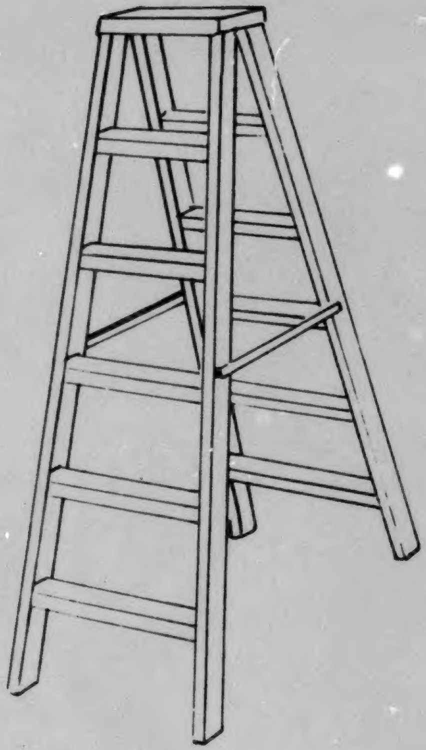
Cylinder Wrench

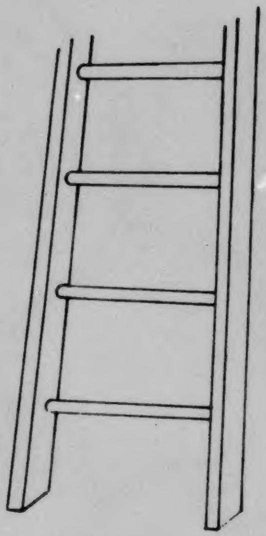
TM-2

S-207-D

Ladders

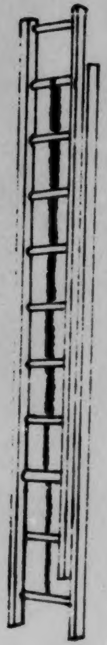
Stepladder



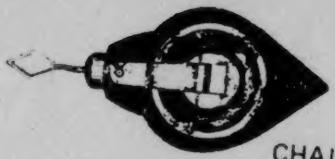


Single Ladder

Extension Ladder



Site Layout and Measuring Tools

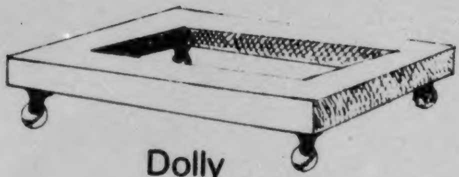


CHALK LINE AND REEL

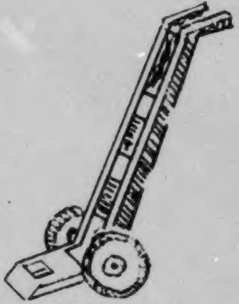
PLUMB BOB

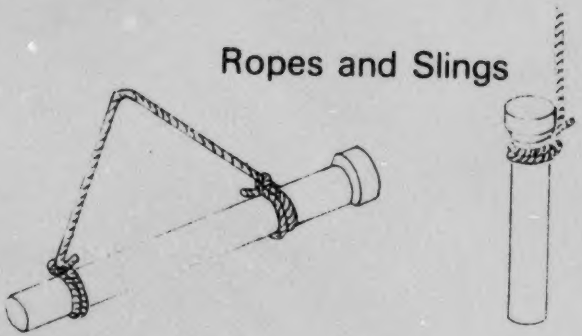
100-FOOT STEEL TAPE

DOLLY, HAND TRUCK, ROPES, AND SLINGS



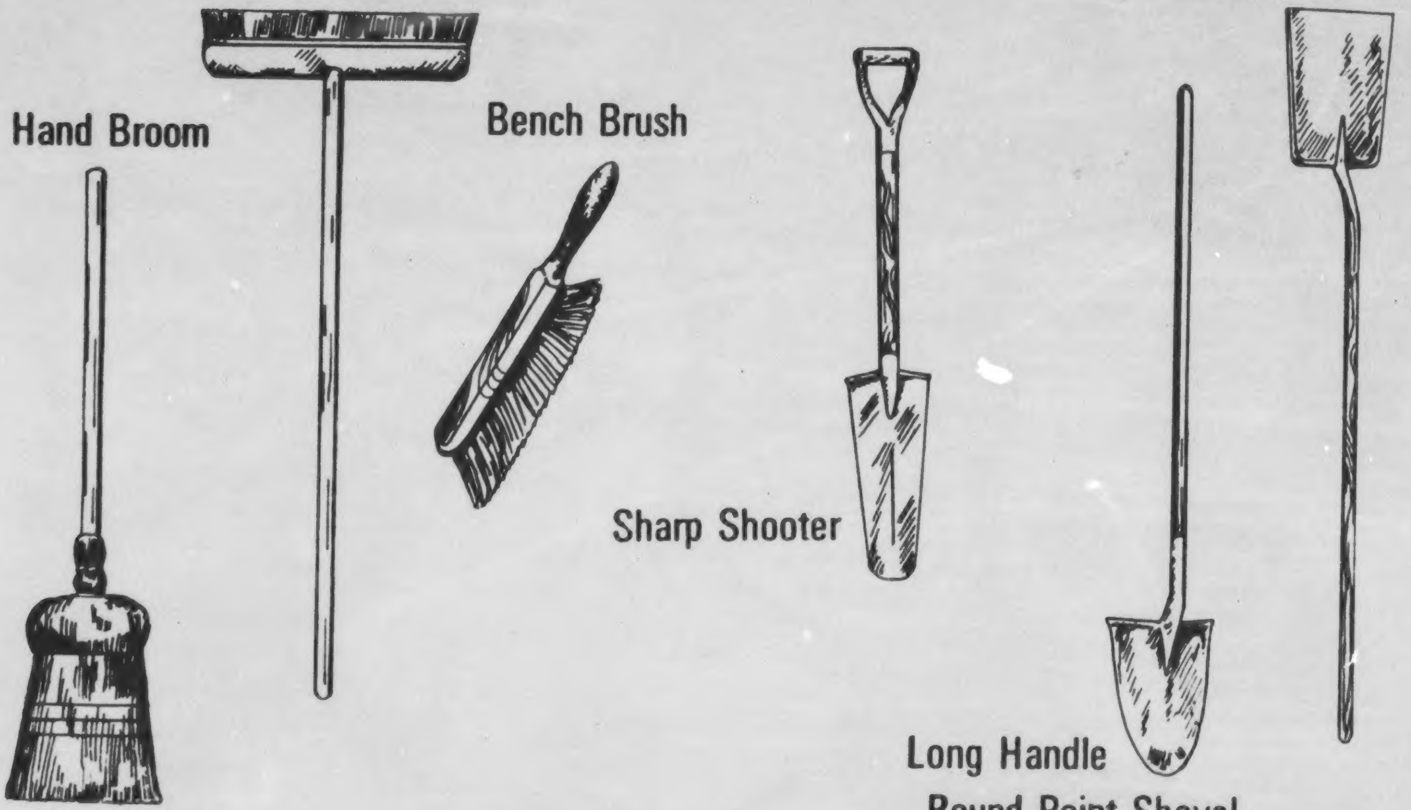
Dolly



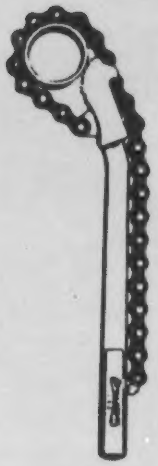


Ropes and Slings

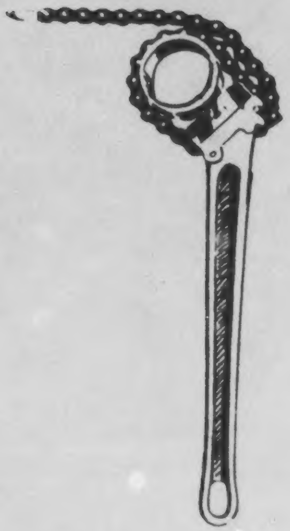
Cleaning and Excavating Equipment



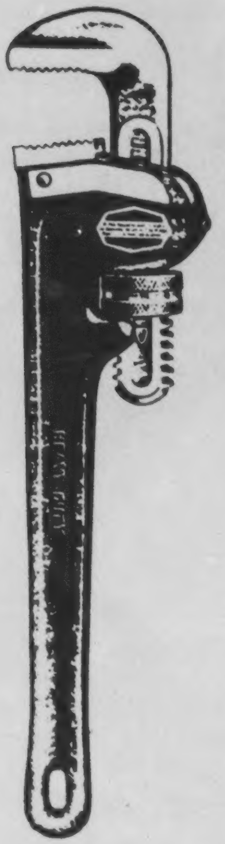
Wrenches



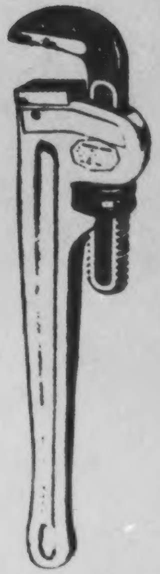
LIGHT DUTY CHAIN WRENCH



HEAVY DUTY CHAIN WRENCH

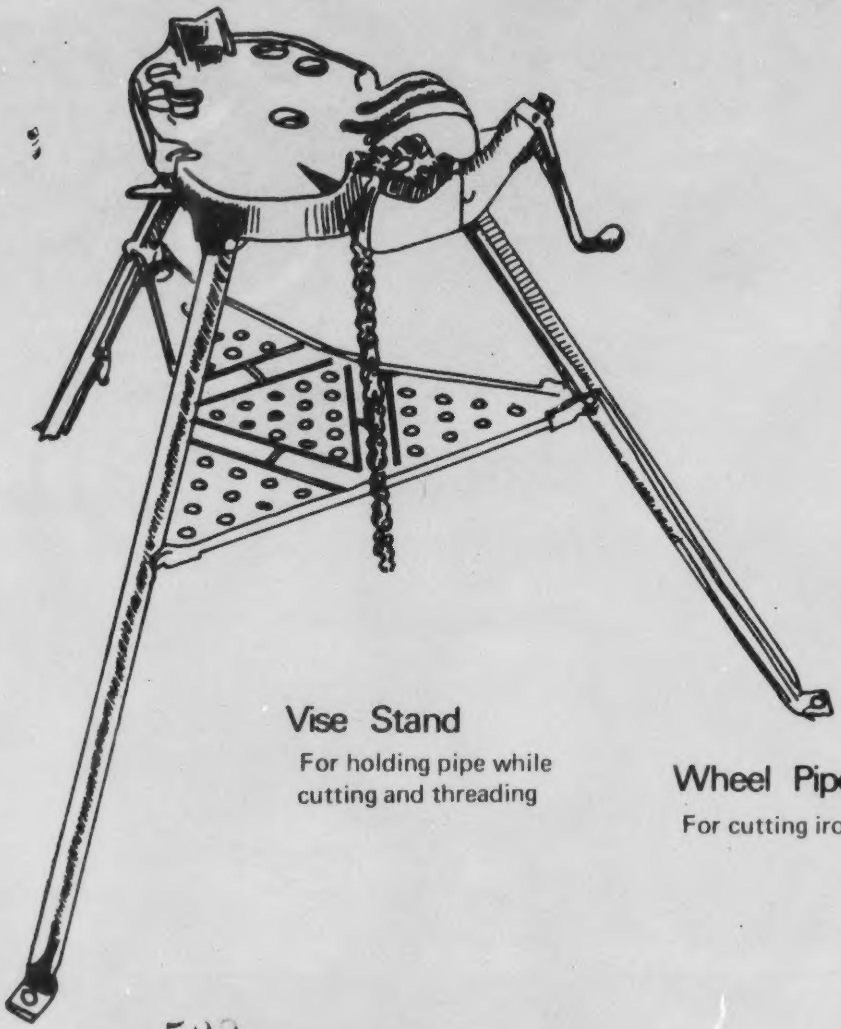


36"STRAIGHT PIPE WRENCH



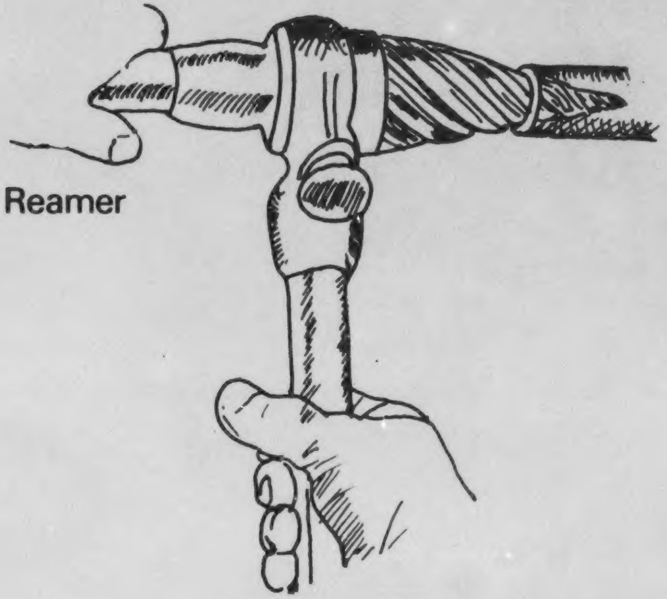
24"STRAIGHT PIPE WRENCH

Pipe Cutting Equipment

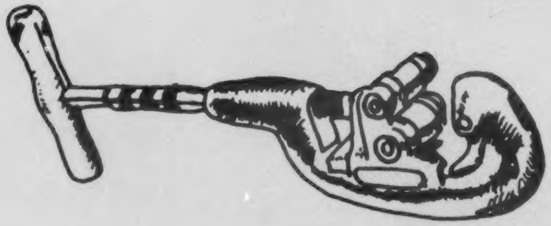


Vise Stand

For holding pipe while cutting and threading



Pipe Reamer



Wheel Pipe Cutter

For cutting iron pipe

EQUIPMENT
UNIT V

JOB SHEET #1--LIGHT AND ADJUST THE AIR-ACETYLENE TORCH

EVALUATION: Given access to tools and equipment, light and adjust the air-acetylene torch. Evaluation will include use of correct safety precautions, correct use of tools, and neatness of work performed.

I. Tools and materials

   A. Air-acetylene torch outfit

   B. Acetylene tank valve wrench

   C. Striker

   D. Safety glasses

II. Procedure

   (NOTE: Tank should be purged before regulator is installed.)

   A. Put on safety glasses

   B. Open tank valve 1/2 of a turn

      (NOTE: Leave tank key on tank valve while using this equipment.)

   C. Check system for leaks with soap bubbles

      (CAUTION: Never check for a gas leak with a flame.)

   D. Open torch handle valve 1/4 of a turn

   E. Strike striker immediately

   F. Upon ignition of flame, open torch volve another 1/2 of a turn

      (CAUTION: If falme does not ignite immediately, shut off valve on handle. Delayed ignition could cause an explosion.)

   G. Adjust flame so that inner blue cone is about 1 1/2" long

(NOTE: If there is an air gap between the inner blue cone and the torch tip, the regulator adjusting screw may need to be turned counterclockwise in order to decrease the pressure.)

H. Extinguish by closing tank valve first

I. Let flame burn itself out

J. Close torch handle valve

K. Roll up hose

L. Put away equipment

EQUIPMENT
UNIT V

JOB SHEET #2--GRIND A FLAT TIP SCREWDRIVER

EVALUATION: Given access to tools and equipment, grind a flat tip screwdriver. Evaluation will include use of safety precautions, correct use of tools and equipment, and accuracy of work performed.

I. Tools and equipment

- A. Flat tip screwdriver
- B. Bench grinder
- C. Water tray
- D. Safety glasses

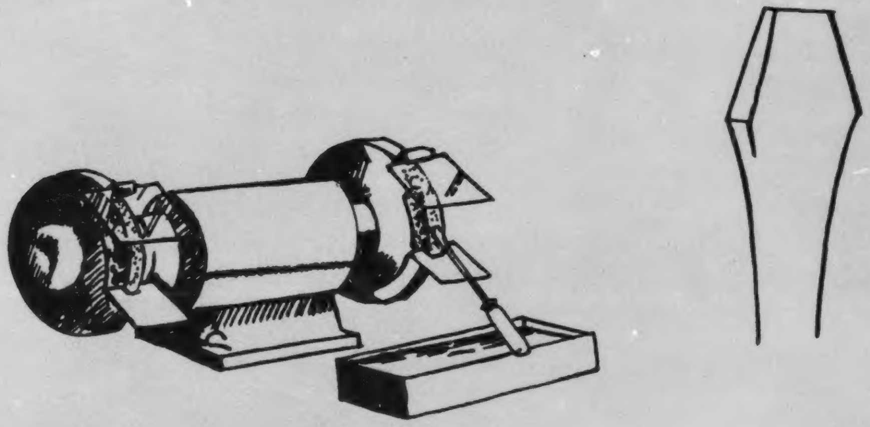
II. Procedure

- A. Put on safety glasses
- B. Adjust clearance of tool rest

  (NOTE: Proper clearance is approximately 1/8" from grinding wheel.)
- C. Turn on grinder

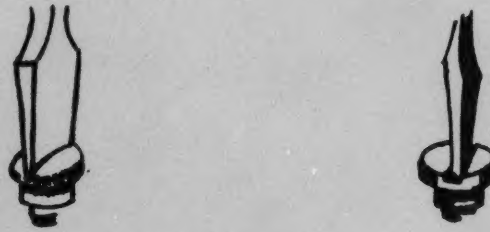
  (NOTE: Dress grinding wheel if necessary.)
- D. Grind tip of blade flat (Figure 1)

FIGURE 1

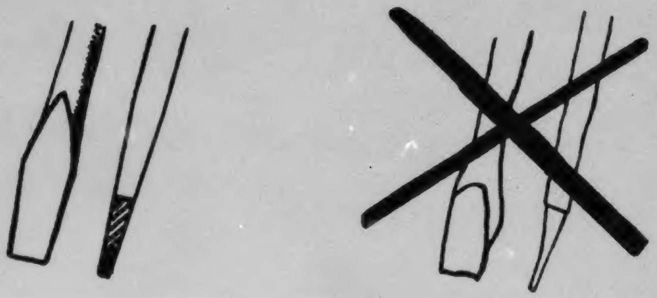


E. Grind sides of blade to manufacturer's original specifications (Figure 2)

FIGURE 2



Ground Right Ground Wrong



(NOTE: Cool tip in tray of water often while grinding to prevent softening of the tip.)

EQUIPMENT
UNIT V

JOB SHEET #3--GRIND THE HEAD OF A COLD CHISEL OR PUNCH

EVALUATION: Given access to tools and equipment, grind the head of a chisel or punch. Evaluation will include use of safety precautions, correct use of tools and equipment, and accuracy of work performed.

I. Tools and materials

   A. Chisel and/or punch

   B. Bench grinder

   C. Water tray

   D. Safety glasses

II. Procedure

   A. Put on safety glasses

   B. Adjust clearance of tool rest

   (NOTE: Proper clearance is approximately 1/8" from grinding wheel.)

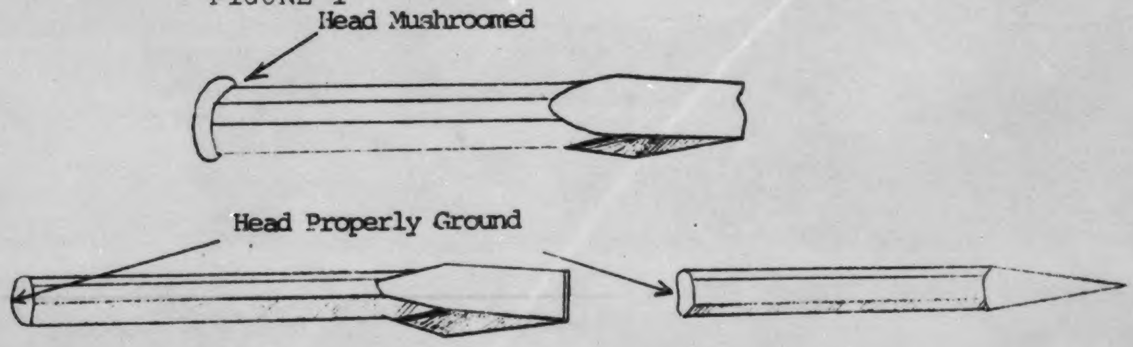
   C. Turn on grinder

   (NOTE: Dress grinding wheel if necessary.)

   D. Grind a bevel on the head (Figure 1)

   (CAUTION: When the head of a punch or chisel is mushroomed, chips could break off during use causing injury to the user.)

FIGURE 1



EQUIPMENT
UNIT V

JOB SHEET #4--SHARPEN A COLD CHISEL

EVALUATION: Given access to tools and equipment sharpen a chisel. Evaluation will include use of safety precautions, correct use of tools and equipment, and accuracy of work performed.

I. Tools and materials

   A. Chisel

   B. Bench grinder

   C. Water tray

   D. Safety glasses

II. Procedure

   A. Put on safety glasses

   B. Adjust clearance of tool rest

   (NOTE: Proper clearance is approximately 1/8" from grinding wheel.)

   C. Turn on grinder

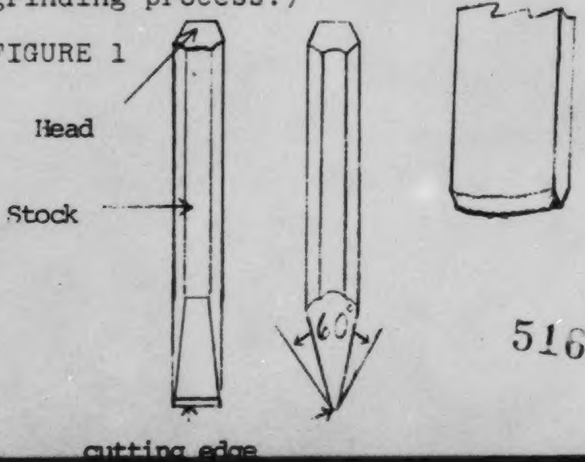
   D. Hold the chisel's cutting edge against the grinding wheel with very little pressure

   (NOTE: This will help to prevent overheating of the chisel's cutting edge. Dip the chisel in the water frequently to cool.)

   E. Grind the edge on a slight curve (Figure 1)

   (CAUTION: Hold the chisel with a firm grip during the grinding process.)

FIGURE 1



EQUIPMENT
UNIT V

NAME________________________

TEST

1. Match the terms on the right to the correct descriptions and definitions.

_____a. Tool used to create a controlled flame which is used for soldering copper fittings

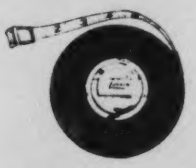
_____b. A colorless, gaseous hydrocarbon made by the action of water on calcium carbide and used as a fuel

_____c. Instrument used to lift heavy objects with the least amount of strain on the worker

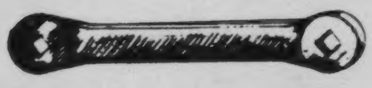
_____d. Electric powered grinding wheel used to sharpen tools and wear away excess metal from various objects

1. Bench grinder
2. Hoist
3. Torch
4. Acetylene

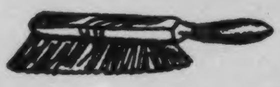
2. Identify equipment generally used to install solar systems



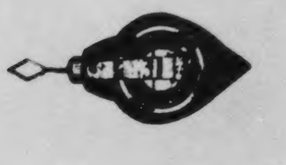
a. ______________________



b. ______________________



c. ______________________



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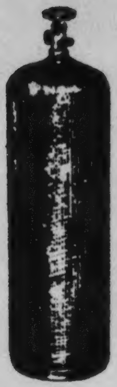

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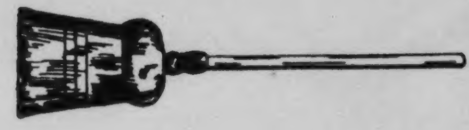

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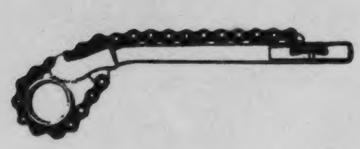

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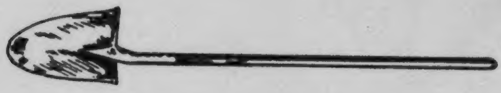

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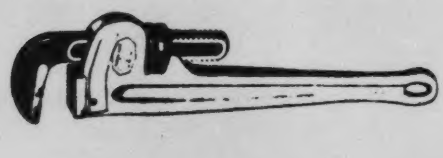

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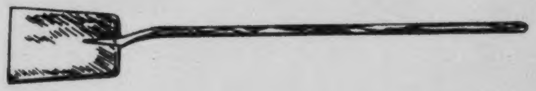

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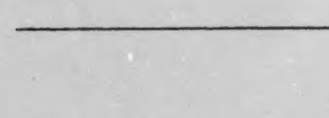

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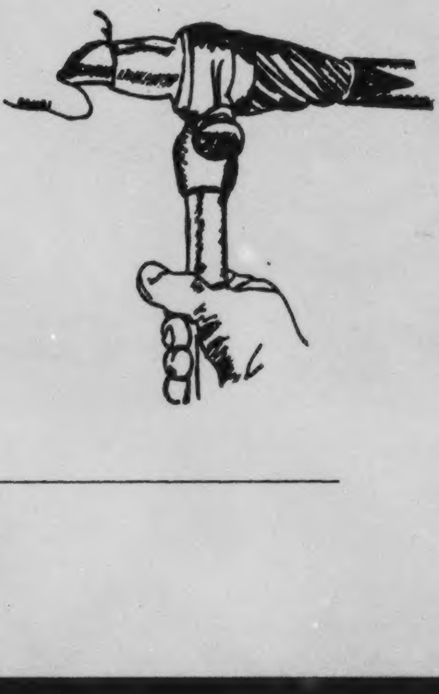

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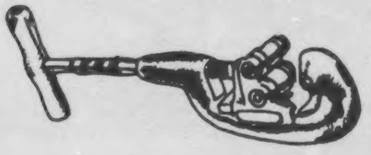
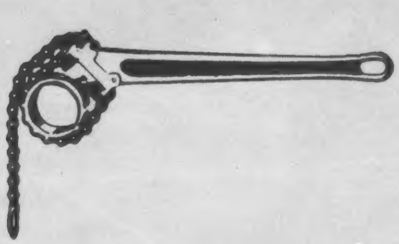
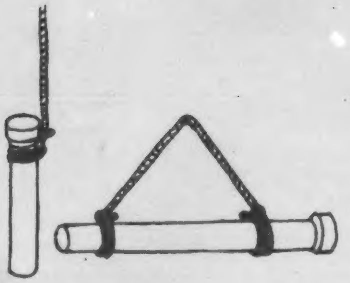
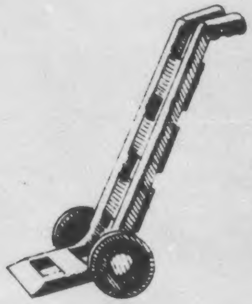




m. ____________________

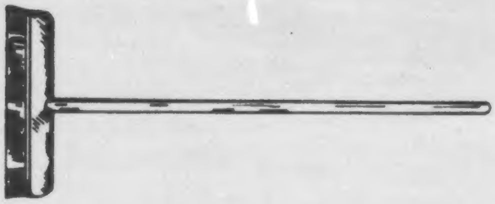
n. ____________________

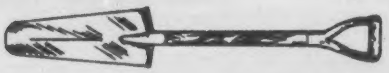




o. ____________________

p. ____________________





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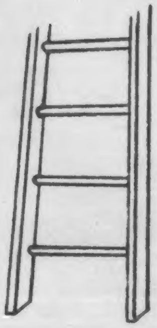
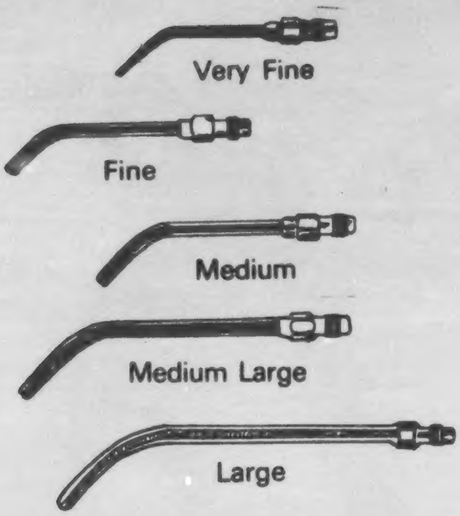
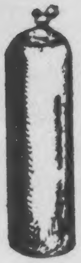
r. ____________________



s. ____________________

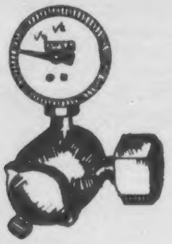
t. ____________________

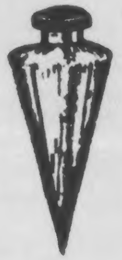




u. ______________________

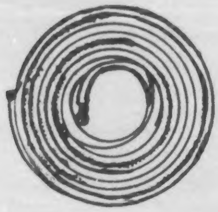
v. ______________________

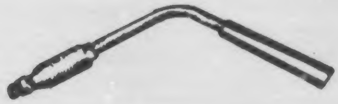




w. ______________________

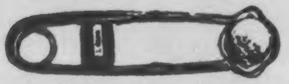
x. ______________________



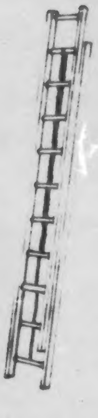


y. ______________________

z. ______________________



aa. ____________________ bb. ____________________



cc. ____________________ dd. ____________________

3. Match the types of equipment on the right to their correct use or care statement.

_____a. Used to heat copper tube and melt solder to make sweat joints

_____b. Used for working short distances above ordinary reach level

_____c. Used to reach the roof of single story buildings

_____d. Used to reach the roof of two-story buildings

_____e. Can transport heavy objects along level surfaces and slight grades

_____f. Can transport heavy objects over rough ground, up and down stairs, up and down steep grades, and over level surfaces

_____g. Are used for general digging purposes

_____h. Are used to make tunnels under sidewalks, shrubs, driveways, porches, or footings

_____i. Are used for cutting straight lines in grass sod, squaring corners of excavations, and helping to make tunnels under sidewalks, shrubs, driveways, or porches

_____j. Help make lifting easier and help prevent strains and bruises

1. Torch
2. Dolly
3. Extension ladder
4. Stepladder
5. Sharp shooter shovel
6. Ropes and sling
7. Square point shovel
8. Round point shovel
9. Hand truck
10. Single ladder

4. Match two safety precaution statements on the right to the correct part of an air-acetylene torch outfit.

a. Regulator

1) _____

2) _____

b. Gauges

1) _____

2) _____

a. Keep glass protected from breaki

b. Do not remove a tip from the tor when it is hot

c. Do not repair a hose with tape

d. Keep all connections to the torc tight

e. Do not attempt to repair a defec tive gauge

f. Do not exceed recommended pressures

c. Hoses

  1) _____

  2) _____

d. Torches

  1) _____

  2) _____

e. Tips

  1) _____

  2) _____

g. Use the manufacturers wrench to remove torch tips

h. Keep hose connections tight

i. Any torch suspected of being faulty should be repaired by a competent serviceman

j. Keep regulator off when not in use

5. Demonstrate the ability to:

   a. Light and adjust the air-acetylene torch.

   b. Grind a flat tip screwdriver.

   c. Grind the head of a cold chisel or punch.

   d. Sharpen a cold chisel.

   (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

EQUIPMENT
UNIT V

ANSWERS TO TEST

1. a. 3
   b. 4
   c. 2
   d. 1
2. a. 100' steel tape
   b. Cylinder wrench (air-acetylene torch outfit)
   c. Bench brush
   d. Chalk line and reel
   e. "B" acetylene tank
   f. Hand broom
   g. Light duty chain wrench
   h. Round point shovel
   i. Straight pipe wrench
   j. Square point shovel
   k. Dolly
   l. Pipe reamer
   m. Wheel pipe cutter
   n. Heavy duty chain wrench
   o. Ropes and slings
   p. Hand truck
   q. Push broom
   r. Sharp shooter shovel
   s. Single ladder

t. Torch handle (Air-acetylene torch)

u. Tips (Air-acetylene torch)

v. "MC" acetylene tank

w. Regulator (air-acetylene torch)

x. Plumb bob

y. Hose (air-acetylene torch)

z. High temperature wraparound flame tip (air-acetylene torch)

aa. Striker (air-acetylene torch)

bb. Vise stand

cc. Step ladder

dd. Extension ladder

3. a. 1

b. 4

c. 10

d. 3

e. 2

f. 9

g. 8

h. 5

i. 7

j. 6

4. a. Regulator

1) f

2) j

b. Gauges

1) a

2) e

c. Hoses
  1) h
  2) c
d. Torches
  1) d
  2) i
e. Tips
  1) b
  2) g

5. Performance skills evaluated to the satisfaction of the instructor.

SOFT SOLDERING
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with soft soldering to the correct definitions and discuss the types of soft solder and fluxes. The student should also be able to list the steps for making a solder joint and the conditions for proper capillary action of solders. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with soft soldering to the correct definitions.
2. Discuss the descriptions of types of soft solder.
3. List ten steps in making a solder joint.
4. Describe the types of flux used in soft soldering.
5. List the four conditions for creating capillary action of solders.
6. Demonstrate the ability to:
    a. Clean, flux, and solder a swage joint.
    b. Solder an inverted swage joint.
    c. Solder a horizontal swage joint.
    d. Soft solder with the oxyacetylene torch.

SOFT SOLDERING
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet.
- B. Provide student with information and job sheets.
- C. Discuss unit and specific objectives.
- D. Discuss information sheet.
- E. Demonstrate and discuss the procedures outlined in the job sheets.
- F. Give test.

II. Student:

- A. Read objective sheet.
- B. Study information sheet.
- C. Complete job sheets.
- D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Job sheets
  1. Job Sheet #1--Clean, Flux, and Solder a Swage Joint
  2. Job Sheet #2--Solder an Inverted Swage Joint
  3. Job Sheet #3--Solder a Horizontal Swage Joint
  4. Job Sheet #4--Soft Solder with the Oxyacetylene Torch

D. Test

E. Answers to test

II. References:

A. The Oxy-Acetylene Handbook. New York, New York: Linde Division/Union Carbide Corp., 1968.

B. "Soldering and Brazing: The Mark of the Craftsman." Refrigeration Service and Contracting. March, 1975, p. 14.

SOFT SOLDERING
UNIT I

INFORMATION SHEET

I. Terms and definitions

  A. Antimony--Alloy which is added to soft solder for added strength

  B. Capillary action--The manner in which the molten solder is drawn into the joint through the proper application of heat

  C. Soft solder--Solder with a melting temperature of 800°F or less, that is used as a filler metal

  D. Flux--Mildly corrosive substance that is applied to a joint prior to soldering to prevent oxidation

  E. Filler metal--Metal which is melted and is used to join two similar or dissimilar metals together

  F. Oxidize--To combine with oxygen

  (NOTE: This will create the accumulation of a film on the tubing that prevents the flow of solder.)

  G. Eutectic solder--Solder having a low melting point

  H. Topped--The process of melting a solder on top of the one that was used to make the joint to insure a leak proof joint

II. Descriptions and uses of types of soft solder

  A. 50-50 solder

    1. All purpose solder for plumbing

    2. Easy to use

    3. Composition

      a. 50% tin

      b. 50% lead

B. 95-5 solder
  1. Usually used only when specified
  2. Hard to use
  3. Composition
    a. 95% tin
    b. 5% antimony

C. 40-60 solder
  1. Will not flow as well as 50-50
  2. Not generally used
  3. Composition
    a. 40% tin
    b. 60% lead

D. 63-37 solder
  1. A eutectic solder
    a. Very strong
    b. Low melting temperature
  2. Used where low melting temperatures are necessary
  3. Composition
    a. 63% tin
    b. 37% lead

E. 97-3 solder
  1. A silver bearing soft solder
    a. Good strength
    b. Excellent flowing qualities
  2. Used for collector loop lines
  3. Used for hot and cold water supply lines
  4. Composition

    - a. 97% tin
    - b. 3% silver

III. Steps for making a solder joint

  - A. Measure length of tube
  - B. Cut tube square
  - C. Ream cut end
  - D. Clean tube end
  - E. Clean fitting socket
  - F. Apply flux to tube end
  - G. Assemble
  - H. Remove excess flux
  - I. Apply heat
  - J. Apply solder
  - K. Allow joint to cool
  - L. Clean the joint

IV. Types of flux for soft solder

  - A. Mildly corrosive paste flux
    - 1. Composed of
      - a. Zinc
      - b. Ammonium
    - 2. Aids in easy flowing of solder

    (NOTE: This flux is recommended for use with 50-50 and 95-5 solder.)

  - B. Liquid self-cleaning fluxes
    - 1. Nonuniform cleaning
    - 2. Could create contamination

V. Conditions for creating capillary action of solders

- A. Proper joint fit
- B. Correct temperature
- C. Properly cleaned joint
- D. Correct flux

SOFT SOLDERING
UNIT I

JOB SHEET #1--CLEAN, FLUX, AND SOLDER A SWAGE JOINT

I. Tools and materials

A. Tubing cutter

B. Reamer

C. Swaging block

D. Swage punch

E. Ball peen hammer

F. Soft copper tubing

(NOTE: Size of swage punch and tubing will be selected by the instructor.)

G. Fine sand cloth

(NOTE: Do not use emery cloth when working with solar systems.)

H. Air-acetylene torch outfit

I. Colored safety glasses

J. Striker

K. Length of soft solder

(NOTE: Type of solder to be used will be selected by the instructor.)

L. Soldering Flux

(NOTE: Flux may be in paste or liquid form.)

M. 2" x 4" x 6" wood block

N. Clean wet towel

O. Pair of pliers to handle hot tubing

II. Procedure

A. Make a swage joint

SOFT SOLDERING
UNIT I

JOB SHEET #1--CLEAN, FLUX, AND SOLDER A SWAGE JOINT

I. Tools and materials

- A. Tubing cutter
- B. Reamer
- C. Swaging block
- D. Swage punch
- E. Ball peen hammer
- F. Soft copper tubing

  (NOTE: Size of swage punch and tubing will be selected by the instructor.)

- G. Fine sand cloth

  (NOTE: Do not use emery cloth when working with solar systems.)

- H. Air-acetylene torch outfit
- I. Colored safety glasses
- J. Striker
- K. Length of soft solder

  (NOTE: Type of solder to be used will be selected by the instructor.)

- L. Soldering Flux

  (NOTE: Flux may be in paste or liquid form.)

- M. 2" x 4" x 6" wood block
- N. Clean wet towel
- O. Pair of pliers to handle hot tubing

II. Procedure

- A. Make a swage joint

N. Heat the joint at one point only (Figure 1)

O. Apply solder to the joint on opposite side from flame

(NOTE: Do not melt solder with torch. When the tubing has been heated to the proper temperature the solder will melt and flow into the swage joint.)

(CAUTION: Overheating of tubing can cause solder to splash when applied.)

P. Discontinue heat and solder application when solder fills the joint

(NOTE: Do not continue to apply solder if it is not flowing into the joint. If the solder will not flow into the joint it will have to be disassembled, cleaned, and the soldering process repeated.)

Q. Turn off torch

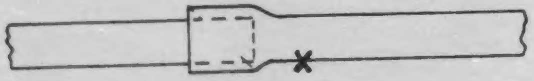
R. Allow solder to cool

S. Clean the joint with a clean damp towel

T. Have instructor inspect

U. Cut swage joint at point X with tube cutters (Figure 2)

FIGURE 2



V. Have instructor inspect the joint for proper fill

W. Clean up area and put away tools if this is the last soldering project of the day

SOFT SOLDERING
UNIT I

JOB SHEET #2--SOLDER AN INVERTED SWAGE JOINT

I. Tools and materials

A. Tubing cutter

B. Reamer

C. Swaging block

D. Swage punch

E. Ball peen hammer

F. Soft copper tubing

(NOTE: Size of swage punch and tubing will be selected by the instructor.)

G. Fine sand cloth

(NOTE: Do not use emery cloth when working with solar systems.)

H. Air-acetylene torch outfit

I. Colored safety glasses

J. Striker

K. Length of soft solder

(NOTE: Type of solder to be used selected by the instructor.)

L. Soldering flux

(NOTE: Flux may be in paste or liquid form.)

M. 2" x 4" x 6" wood block

N. Clean wet towel

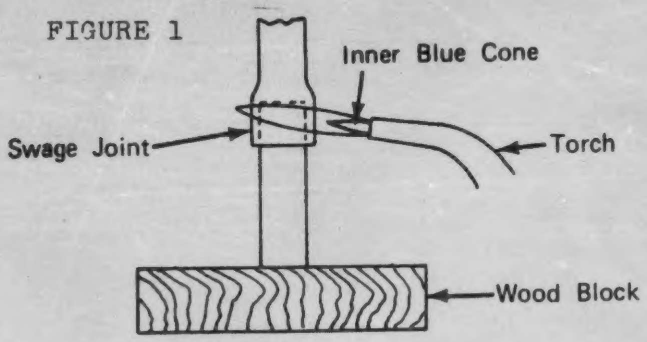
O. Pair of pliers to handle hot tubing

II. Procedure

A. Prepare and swage tubing

B. Place tubing in wood block (Figure 1)

FIGURE 1



C. Put on safety glasses

D. Light and adjust torch

E. Apply heat to swage joint (Figure 1)

(NOTE: The inner blue cone of the flame should be approximately 1/2" away from the swage joint.)

F. Heat the joint at one point only (Figure 1)

(NOTE: The heat should be applied on the upper part of the swage joint so that the capillary action will pull the solder up into the joint.)

G. Apply solder to the joint on opposite side from flame

(NOTE: Do not melt solder with torch. When the tubing has been heated to the proper temperature the solder will melt and flow into the swage joint.)

(CAUTION: Overheating of the tubing can cause solder to splash when applied.)

H. Discontinue heat and solder application when solder fills the joint

(NOTE: Do not continue to apply solder if it is not flowing into the joint. If the solder will not flow into the joint it will have to be disassembled, cleaned, and the soldering process repeated.)

I. Turn off torch

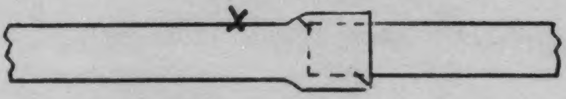
J. Allow solder to cool

K. Clean the joint with a clean damp towel

L. Have instructor inspect

M. Cut swage joint at point X with tubing cutters (Figure 2)

FIGURE 2



N. Have instructor inspect the joint for proper fill

O. Clean up area and put away tools if this is the last soldering project of the day

SOFT SOLDERING
UNIT I

JOB SHEET #3--SOLDER A HORIZONTAL SWAGE JOINT

I. Tools and materials

A. Tubing cutter

B. Reamer

C. Swaging block

D. Swage punch

E. Ball peen hammer

F. Soft copper tubing

(NOTE: Size of swage punch and tubing will be selected by the instructor.)

G. Fine sand cloth

(NOTE: Do not use emery cloth when working with solar systems.)

H. Air-acetylene torch outfit

I. Colored safety glasses

J. Striker

K. Length of soft solder

(NOTE: Type of solder to be used selected by the instructor.)

L. Soldering flux

(NOTE: Flux may be in paste or liquid form.)

M. 2" x 4" x 6" wood block

N. Clean wet towel

O. Pair of pliers to handle hot tubing

II. Procedure

A. Cut three pieces of tubing 3" long

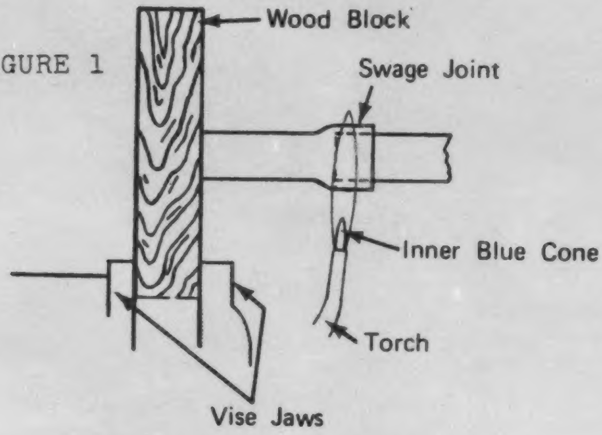
B. Ream one end of two pieces

C. Swage the two reamed pieces

D. Clean, flux, and assemble the pieces of tubing

E. Place tubing in block (Figure 1)

FIGURE 1



F. Put on safety glasses

G. Light and adjust torch

H. Apply heat to swage joint (Figure 1)

(NOTE: The inner blue cone of the flame should be approximately 1/8" away from the swage joint.)

I. Move the torch around, heating the entire joint

J. Apply solder to the joint on opposite side from flame

(NOTE: Do not melt solder with torch. When the tubing has been heated to the proper temperature the solder will melt and flow into the swage joint.)

(CAUTION: Overheating of the tubing can cause solder to splash when applied.)

K. Discontinue heat and solder application when solder fills the joint

(NOTE: Do not continue to apply solder if it is not flowing into the joint. If the solder will not flow into the joint it will have to be disassembled, cleaned, and the soldering process repeated.)

L. Turn off torch

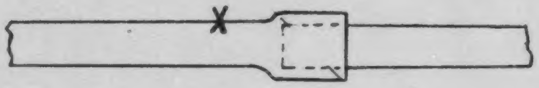
M. Allow solder to cool

N. Clean the joint with a clean damp towel

O. Have instructor inspect

P. Cut swage joint at point X with tubing cutter (Figure 2)

FIGURE 2



Q. Have instructor inspect the joint for proper fill

R. Clean up area and put away tools if this is the last soldering project of the day

SOFT SOLDERING
UNIT I

JOB SHEET #4--SOFT SOLDER WITH THE OXYACETYLENE TORCH

I. Tools and materials

A. Oxy-acetylene torch outfit

B. Colored safety glasses

C. Striker

D. Soft copper tubing

E. Length of selected soft solder

(NOTE: Type of solder to be used will be selected by the instructor.)

F. Soldering flux

G. Swage punch

(NOTE: Size of tubing and swage punch will be selected by the instructor.)

H. 2" x 4" x 6" block of wood

I. Clean wet towel

J. Pair of pliers

K. Hacksaw

II. Procedure

A. Cut two pieces of tubing 3" long

B. Ream one end of one piece

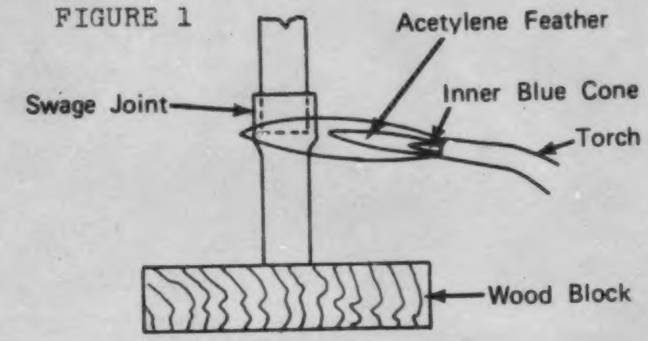
C. Swage the reamed end of the tubing

D. Clean, flux, and assemble the pieces of tubing

E. Place tubing in block (Figure 1)

(NOTE: If a vise is used to hold the tubing, the swage joint should be well above the vise jaws. The vise jaws will absorb heat and make a successful solder joint difficult.)

FIGURE 1



F. Put on safety glasses

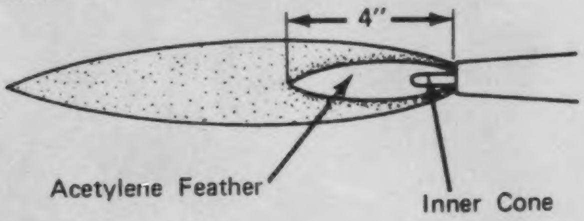
G. Light and adjust torch for neutral flame

H. After obtaining neutral flame add more acetylene (Figure 2)

(NOTE: For soft soldering the acetylene feather should be about 4" long.)

I. Use the acetylene feather for soldering

FIGURE 2



J. Apply heat to swage joint

K. Move the torch around, heating the entire joint

L. Apply solder to the joint at a point opposite the flame

(NOTE: Do not melt solder with torch. When the tubing has been heated to the proper temperature, the solder will melt and flow into the swage joint.)

(CAUTION: Overheating of the tubing can cause solder to splash when applied.)

M. Discontinue heat and solder application when solder fills the joint

(NOTE: Do not continue to apply solder if it is not flowing into the joint. If the solder will not flow into the joint it will have to be disassembled. cleaned, and the soldering process repeated.)

N. Remove the heat as soon as the solder flows into the joint

O. Turn off torch

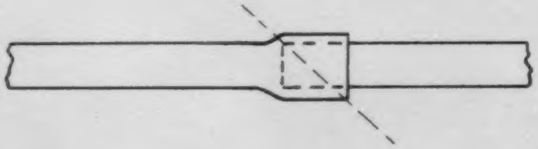
P. Allow solder to cool

Q. Clean the joint with a clean wet towel

R. Have instructor inspect

S. Cut swage joint at a diagonal with a hacksaw (Figure 3)

FIGURE 3



T. Have instructor inspect the cut joint

U. Clean up area and put away tools

SOFT SOLDERING
UNIT I

NAME________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. The process of melting a solder on top of the one that was used to make the joint to insure a leak proof joint

_____b. Solder having a low melting point

_____c. To combine with oxygen

_____d. Metal which is melted and is used to join two similar or dissimilar metals together

_____e. Mildly corrosive substance that is applied to a joint prior to soldering to prevent oxidation

_____f. Solder with a melting temperature of 800°F or less, that is used as a filler metal

_____g. Alloy which is added to soft solder for added strength

_____h. The manner in which the molten solder is drawn into the joint through the proper application of heat

1. Flux
2. Eutectic solder
3. Soft solder
4. Antimony
5. Oxidize
6. Topped
7. Filler metal
8. Capillary action

2. Discuss the descriptions of types of soft solder.

a. 50-50

1. Composition

a. ______________________

b. ______________________

b. 95-5

1. Composition

a. ____________________

b. ____________________

c. 40-60

1. Composition

a. ____________________

b. ____________________

d. 97-3

1. Composition

a. ____________________

b. ____________________

3. List ten steps in making a solder joint.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

g. ____

h. ____

i. ____

j. ____

4. Describe the types of flux used in soft soldering.

a. Mildly corrosive paste flux

1-Purpose____

2-Recommended for____________and____________solders

5. List four conditions for creating capillary action of solders.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

6. Demonstrate the ability to:

a. Clean, flux, and solder a swage joint.

b. Solder an inverted swage joint.

c. Solder a horizontal swage joint.

d. Soft solder with the oxyacetylene torch.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

SOFT SOLDERING
UNIT I

ANSWERS TO TEST

1. a. 6
   b. 2
   c. 5
   d. 7
   e. 1
   f. 3
   g. 4
   h. 8

2. Discussion should include:
   - a. 50-50 solder
     - 1. Composition
       - a. 50% tin
       - b. 50% lead
   - b. 95-5 solder
     - 1. Composition
       - a. 95% tin
       - b. 5% antimony
   - c. 40-60 solder
     - 1. Composition
       - a. 40% tin
       - b. 60% lead
   - d. 97-3 solder
     - 1. Composition
       - a. 97% tin
       - b. 3% silver

3. List any ten of the following.
   - a. Measure length of tube

- b. Cut tube square
- c. Ream cut end
- d. Clean tube end
- e. Clean fitting socket
- f. Apply flux to tube end
- g. Assemble
- h. Remove excess flux
- i. Apply heat
- j. Apply solder
- k. Allow joint to cool
- l. Clean the joint

4. Description should include:
    - a. Mildly corrosive paste flux
        - 1. Aids in easy flowing of solder
        - 2. Recommended for use with 50-50 and 95-5 solders

5. a. Proper joint fit
    - b. Correct temperature
    - c. Properly cleaned joint
    - d. Correct flux

6. Performance skills evaluated to the satisfaction of the instructor

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to light, adjust, and turn off an oxyacetylene cutting outfit. He should also be able to make ninety degree cuts and cut holes in mild steel. In addition, he should be able to select the proper size welding tip and to choose the correct filler rod. He should be able to demonstrate the ability to do fusion welding with or without filler rod. He should be able to demonstrate the ability to apply flux to a filler rod and construct a butt weld using the brazing process. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with oxyacetylene cutting, welding, and brazing to the correct definitions.
2. Identify the parts of a cutting torch.
3. Describe the results of a flashback.
4. List in the proper order the steps to follow in case of a flashback.
5. Name five factors that determine fusion weld quality.
6. List four properties of a good weld.
7. Name two factors that determine tip size selection in oxyacetylene fusion welding.
8. List two factors that determine the filler rod selection in oxyacetylene fusion welding.
9. State the purpose of the filler rod.
10. Identify three types of oxyacetylene fusion welding flames.
11. List two advantages of braze welding.

12. List three disadvantages of braze welding.

13. Match the characteristics of the elements found in the filler rods used in braze welding to the appropriate element.

14. Name two reasons for having a chemically clean metal surface in braze welding.

15. Name two methods for removing oxides from a clean metal surface.

16. List three purposes of flux.

17. Match the reaction of molten bronze to the appropriate base metal temperature that brings about the reaction.

18. Select from a list the proper tip size, acetylene pressure, and oxygen pressure for a given metal thickness.

19. State an acceptable lens shade number for oxy-acetylene welding.

20. Demonstrate the ability to:
    a. Set up equipment for oxyacetylene cutting.
    b. Turn on, light, adjust to a neutral flame, and turn off the oxyacetylene cutting equipment.
    c. Make ninety degree cuts on mild steel and re-start a cut.
    d. Cut a hole in mild steel.
    e. Lay beads on gauge metal without filler rod.
    f. Lay beads on gauge metal with filler rod.
    g. Weld butt joints with filler rod.
    h. Braze weld a square groove butt joint.

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet.
- B. Provide student with information and job sheets.
- C. Make transparencies.
- D. Discuss unit and specific objectives.
- E. Discuss information sheet.
- F. Demonstrate and discuss the procedures outlined in the job sheets.
- G. Give test.

II. Student:

- A. Read objective sheet.
- B. Study information sheet.
- C. Complete job sheets.
- D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Transparency masters
    1. TM 1--Parts of a Torch Body and Cutting Attachment
    2. TM 2--Oxyacetylene Fusion Welding Flames
- D. Job sheets
    1. Job Sheet #1--Set Up Equipment for Oxyacetylene Cutting

2. Job Sheet #2--Turn On, Light, Adjust to a Neutral Flame, and Turn Off the Oxyacetylene Cutting Equipment

3. Job Sheet #3--Make Ninety Degree Cuts on Mild Steel and Restart a Cut

4. Job Sheet #4--Cut a Hole in Mild Steel

5. Job Sheet #5--Lay Beads on Gauge Metal Without Filler Rod

6. Job Sheet #6--Lay Beads on Gauge Metal With Filler Rod

7. Job Sheet #7--Weld Butt Joints With Filler Rod

8. Job Sheet #8--Braze Weld a Square Groove Butt Joint

E. Test

F. Answers to test

II. References:

A. The Oxy-Acetylene Handbook. New York, New York: Union Carbide Corporation/Linde Division 1960

B. Welding Curriculum. Stillwater, Oklahoma: State Department of Vocational and Technical Education, 1974.

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. Backfire--Momentary burning back of the flame into the tip

B. Flame cutting--Process by which iron or steel is heated to a temperature where it can be rapidly oxidized by high purity oxygen flowing under pressure through a cutting torch

(NOTE: As the metal is oxidized, the preheat flame maintains the temperature necessary to keep the oxidation process going in a narrow zone across the length of the base metal.)

C. Oxide--Term usually applied to rust, corrosion, coating, film, or scale

(NOTE: Oxygen combines with the metal causing oxides.)

D. Oxidizing--Combing oxygen with another substance

Example: A metal is oxidized when the metal is cut

E. Fusion welding--Joining pieces of metal by heating the adjoining edges to the fusion or melting point and allowing them to flow or run together and then cool

F. Penetration--Distance from the original surface of the base metal to the point at which fusion ceases

G. Base metal--Metal being welded

H. Inner cone--Inner white part of the neutral flame

I. Tack weld--Short weld used for temporarily holding material in place

J. Braze welding--Heating the base metal to a dull red color and depositing a bead over the seam (joint) with a bronze filler rod; the base metal is not melted

K. Malleability--Property of metals which allows them to be bent or permanently distorted without rupture; opposite of brittleness

L. Tinning operation--Melting a small amount of bronze rod onto the surface and allowing it to spread along the entire seam (joint)

(NOTE: It is this flow of thin film of bronze which is known as tinning.)

M. Flux-- Chemical used to clean metals and to promote fusion during the welding process

(NOTE: Do not confuse this type of flux with silver brazing flux.)

N. Puddle--That portion of a weld that is molten at the place the heat is supplied

II. Parts of a cutting torch (Transparency 1)

A. Oxygen fitting

B. Acetylene fitting

C. Oxygen torch valve

D. Acetylene torch valve

E. Torch body

F. Oxygen cutting lever

G. Oxygen preheat valve

H. Tip nut

I. Slip-in tip

J. Preheat orifice--Heats metal to kindling point (cherry red) of approximately 1600°F

K. Cutting orifice--Removes oxidized metal

(NOTE: The selection of the correct tip for the job is determined by the thickness of metal, size of tip orifices, and the oxygen cutting pressures. See manufacturer's recommendations.)

III. Results of a flashback

A. Fire inside torch

B. Disappearance of flame followed by

1. Squealing or hissing noise inside torch

2. Sparks coming from the torch

3. Smoke coming from the torch

IV. Steps to follow in case of flashback

A. Close oxygen preheat valve

- B. Close oxygen torch valve
- C. Close acetylene torch valve
- D. Release oxygen regulator screw
- E. Release acetylene regulator screw
- F. Examine acetylene unit
- G. Reset regulator pressure
- H. Light torch

  (NOTE: If heavy smoke comes out of the torch tip and the torch body becomes hot, the flashback has probably traveled past the mixing chamber into the hose. In this case, shut off the oxygen cylinder valve and the acetylene cylinder valve, then notify your instructor.)

V. Factors determining fusion weld quality

- A. Proper flame adjustment
- B. Angle of tip
- C. Distance from work
- D. Speed of travel
- E. Movement of tip

VI. Properties of a good weld

- A. Consistent width
- B. Straightness
- C. Slightly crowned
- D. Fused into base metal
- E. Clean appearance

VII. Factors determining tip size selection

- A. Metal thickness
- B. Size of welding rod

  (NOTE: Always use manufacturer's recommendations on tip size.)

VIII. Factors determining filler rod selection

- A. Rod with similar properties as base metal
- B. Thickness of metal

  (NOTE: A general rule is to use a rod with a diameter equal to the thickness of the base metal.)

IX. Purpose of filler rod--To add strength to weld or joint

X. Oxyacetylene fusion welding flames (Transparency 2)

- A. Carburizing flame
  - 1. Contains excess of acetylene

    (NOTE: An acetylene feather is visible on the inner cone.)
  - 2. Recommended flame for cutting cast iron
  - 3. Introduces carbon into weld, causing hardening of the metal

    (NOTE: The resultant weld is weak.)
- B. Neutral flame
  - 1. Burns equal amounts of oxygen and acetylene
  - 2. Identified by clear, well defined white cone
  - 3. Temperature 5950°
- C. Oxidizing flame
  - 1. Burns excess of oxygen
  - 2. Identified by short white inner cone
  - 3. Oxidizes the metal causing it to harden and become brittle
  - 4. Not recommended for average cutting
  - 5. Is the hottest flame
  - 6. A slightly oxidizing flame is recommended for brazing

XI. Advantages of braze welding

- A. Less possibility of destroying main characteristics of base metal
  - 1. Base metal does not have to be heated to a molten condition
    - a. This increases the speed of joining metals
    - b. Less gas is consumed for a given job
  - 2. In repairing malleable castings, there is less danger of its losing its ductile properties
- B. The low degree of heat minimizes expansion and contraction forces
- C. Less need for extensive preheating

XII. Disadvantages of braze welding

- A. Not recommended for parts which are to be raised to temperatures higher than the melting point of bronze, either in service or during heat treatment
- B. Bronze will lose its strength at temperatures above 500°F
- C. It cannot be used on metal where stress is a factor
- D. Bronze may have corrosion resistant properties which differ from those of the base metal being used

XIII. Characteristics of the elements found in the filler rods used in braze welding

- A. Consist of copper alloys containing about 60 percent copper and 40 percent zinc which:
  - 1. Produce a high tensile strength
  - 2. Increase ductility
- B. Contain small quantities of tin, iron, manganese, and silicon which help to:
  - 1. Deoxidize the weld metal
  - 2. Decrease the tendency to fume
  - 3. Increase the free flowing action of the molten metal
  - 4. Increase the hardness of the deposited metal for greater wear resistance

XIV. Reasons for having a chemically clean metal surface in braze welding

A. To guarantee the molten bronze will stick to the base metal

B. To have a stronger bond on base metal

XV. Methods for removing oxides

A. Mechanical--Wire brush or grinder

B. Chemical--Flux

(NOTE: Both methods should be employed to completely remove the oxides.)

XVI. Purposes of the flux

(NOTE: These purposes of flux pertain to fusion brazing and do not apply to the purposes of flux for silver brazing.)

A. Chemically cleans the base metal

B. Prevents oxidation of the filler metal

C. Floats and removes the oxides already present

D. Increases the flow of the filler metal

E. Increases the ability of the filler metal to adhere to the base metal

F. Brings the filler metal into immediate contact with the metals being joined

G. Permits the filler metal to penetrate the pores of the base metal

Color of base metal when the proper temperature is obtained--Dull red

(NOTE: Base metal will begin to glow.)

XVII. Reaction of molten bronze at different base metal temperatures

A. Not hot enough--The molten bronze will not flow over the surface but will form into drops

B. Medium--The molten bronze will spread out evenly and flow over a considerable area

C. Too hot--The molten bronze will tend to boil and to form little balls

6

XVIII. WELDING TIP SIZE AND APPLICATION

TIP SIZE	DRILL SIZE	LENGTH OF AVERAGE INNER FLAME CONE	OXYGEN PRESSURE P.S.I.		ACETYLENE PRESSURE P.S.I.		METAL THICKNESS
			Min.	Max.	Min.	Max.	
000	75	7/32"	1/2	2	1/2	2	up to 1/32"
00	70	7/32"	1	2	1	2	1/64"-3/64"
0	65	3/8"	1	3	1	3	1/32"-5/64"
1	60	3/8"	1	4	1	4	3/64"-3/32"
2	56	3/8"	2	5	2	5	1/16"-1/8"
3	53	3/8"	3	7	3	7	1/8"-3/16"
4	49	5/8"	4	10	4	10	3/16"-1/4"
5	43	1"	5	12	5	15	1/4"-1/2"
6	36	1-1/16"	6	14	6	15	1/2"-3/4"
7	30	1-1/4"	7	16	7	15	3/4"-1-1/4"
8	29	1-1/4"	9	19	8	15	1-1/4"-2"
9	28	1-7/16"	10	20	9	15	2"-2-1/2"
10	27	1-7/16"	11	22	10	15	2-1/2"-3"
11	26	1-7/16"	13	24	11	15	3"-3-1/2"
12	25	1-1/2"	14	28	12	15	3-1/2"-4"

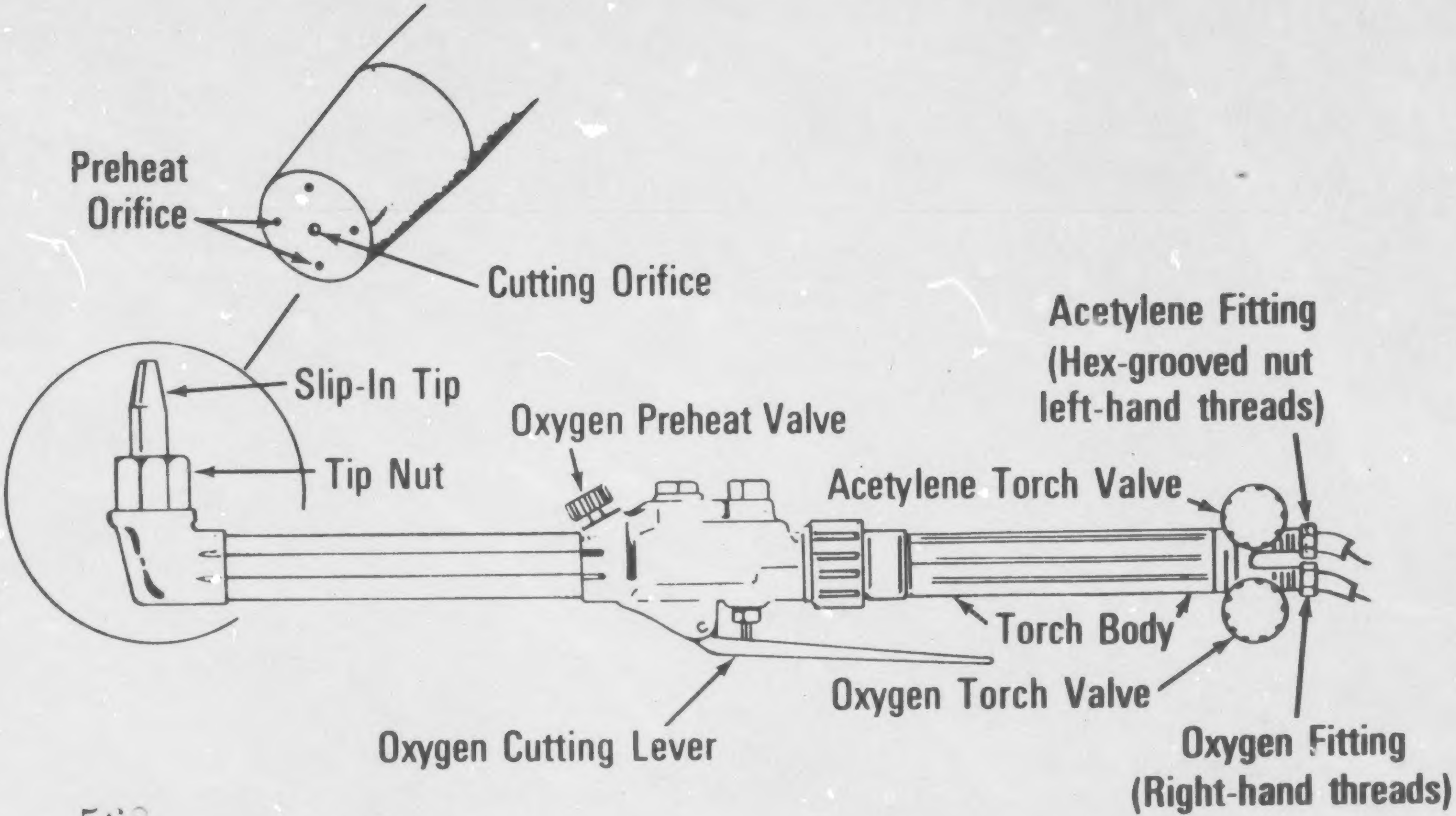
TABLE 1

XIX. Safety lens

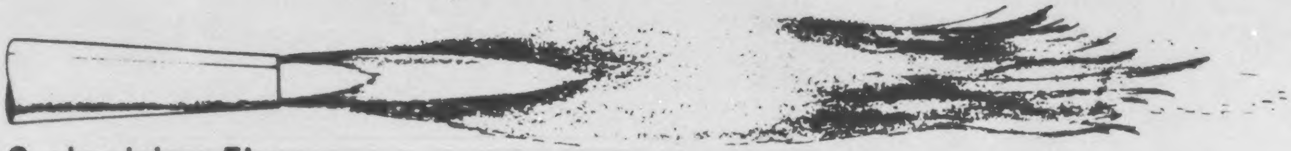
LENS SHADE SELECTOR

Types of operation	Shade number
Soldering	2
Torch brazing	3 or 4
Oxygen cutting	
0-1 inch	3 or 4
1-6 inches	3 or 5
6 inches and over	5 or 6
Gas welding	
0-1/8 inch	4 or 5
1/8-1/2 inch	5 or 6
1/2 inch and over	6 or 8

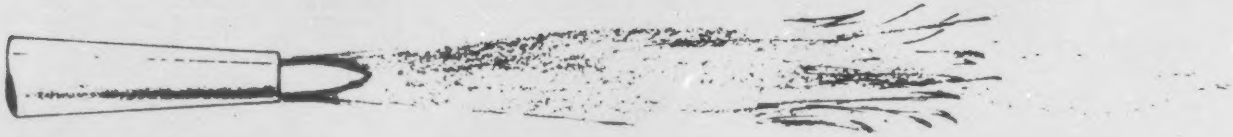
Parts of a Cutting Torch



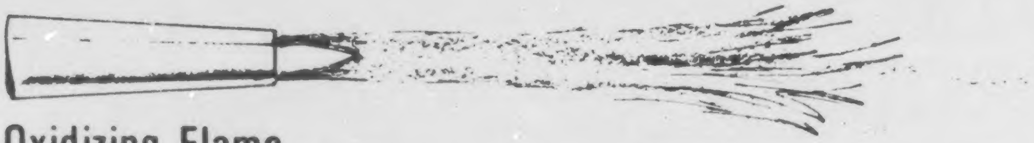
Oxyacetylene Fusion Welding Flames



Carburizing Flame



Neutral Flame



Oxidizing Flame

S-45-E

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT II

JOB SHEET #1--SET UP EQUIPMENT FOR OXYACETYLENE CUTTING

I. Tools and materials

- A. Oxygen cylinder
- B. Acetylene cylinder
- C. Oxygen regulator
- D. Acetylene regulator
- E. Hoses
- F. Wrench
- G. Cylinder holder
- H. Water container
- I. Soap
- J. Clean paintbrush
- K. Torch body with tips

II. Procedure

- A. Fasten cylinders in a vertical position
- B. Remove caps from cylinders
- C. Crack valves of each cylinder, then close valves
- D. Connect oxygen regulator to oxygen cylinder
  1. Turn adjusting screw on regulator counterclockwise until tension on spring is released
  2. Slowly turn cylinder valve wide open
- E. Connect acetylene regulator to acetylene cylinder
  1. Turn adjusting screw on regulator counterclockwise until tension on spring is released
  2. Open cylinder valve 1/2 to 3/4 of a turn (never more than 1 1/2 turns)

F. Connect acetylene hose to acetylene regulator and purge hose

G. Connect oxygen hose to oxygen regulator and purge hose

H. Connect torch body to oxygen and acetylene hose and close both valves on torch body

I. Attach cutting attachment to torch body

(NOTE: The tip size is determined by the thickness of metal to be cut and the manufacturer's recommendations.)

J. Close oxygen preheat valve on cutting attachment

K. Turn adjusting screw on oxygen regulator clockwise until correct working pressure is reached

L. Turn adjusting screw on acetylene regulator clockwise until correct working pressure is reached

M. Test all connections for leaks with soap suds and water

(NOTE: Apply soap suds with a clean paintbrush.)

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT II

JOB SHEET #2--TURN ON, LIGHT, ADJUST TO A NEUTRAL FLAME, AND TURN OFF THE OXYACETYLENE CUTTING EQUIPMENT

I. Tools and materials

- A. Oxygen cylinder
- B. Acetylene cylinder
- C. Hoses
- D. Oxygen and acetylene regulators
- E. Torch body
- F. Cutting attachment with slip-in tip
- G. Cylinder holder and hose rack
- H. Striker
- I. Wrench
- J. Gloves
- K. Colored safety glasses
- L. Coveralls or protective clothing

II. Procedure

A. Turn on, light, and adjust the cutting torch to a neutral flame

1. Check all cylinder, regulator, and torch valves to make sure they are off
2. Open acetylene cylinder valve 1/2 to 3/4 of a turn (never more than 1 1/2 turns)
3. Open acetylene valve on torch one turn
4. Turn adjusting screw on acetylene regulator clockwise until desired pressure is reached

   (NOTE: Oxygen and acetylene pressures and size of tip depend upon the thickness of the metal to be cut. Use pressures and tip sizes recommended by the manufacturers.)

5. Close acetylene valve on torch

6. Open oxygen cylinder valve all the way

7. Open oxygen torch valve all the way

8. Open oxygen preheat valve on cutting attachment one turn

9. Turn adjusting screw on oxygen regulator clockwise until desired pressure is reached

10. Close oxygen preheat valve on cutting attachment

11. Open acetylene valve on torch 1/4 turn

12. Light the torch with striker and adjust until smoke on flame clears

13. Open oxygen preheat valve slowly and adjust to a neutral flame

14. Depress the oxygen cutting lever and check to see that a neutral flame is present

    (NOTE: If necessary, adjust the oxygen preheat valve with the oxygen cutting lever depressed until a neutral flame is secured.)

B. Turn off the flame and oxyacetylene unit

1. Close acetylene valve on torch

2. Close oxygen preheat valve

3. Close acetylene cylinder valve

4. Close oxygen cylinder valve

5. Open acetylene valve on torch

    (NOTE: When gauges reach 0, close torch valve and release adjusting screw on acetylene regulator by turning counterclockwise.)

6. Open oxygen preheat valve on torch

    (NOTE: When gauges reach 0, close oxygen preheat valve and release adjusting screw on oxygen regulator by turning counterclockwise.)

7. Close oxygen valve on torch

8. Place torch and hose on hanger or brackets provided

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT II

JOB SHEET #3--MAKE NINETY DEGREE CUTS ON MILD STEEL AND RESTART A CUT

I. Tools and materials

  A. Cutting outfit with tip assembly

  B. Mild steel plate 1/4" to 1/2" thick, 4" wide or wider, 8" long or longer

  C. Soapstone with a sharp point or edge

  D. Straight edge

  E. Gloves

  F. Welding goggles with #4 lens

  G. Pliers

  H. Protective clothing

  I. Striker

  J. Welding or cutting table

  K. Slag box

  L. Can of water

  M. Cutting tip

II. Procedure

  A. Make ninety degree cut

    1. Mark four parallel lines 2" apart on plate to be cut

    2. Adjust oxygen regulator

    3. Adjust acetylene regulator

    4. Place plate to be cut over slag box

    5. Light torch

    6. Adjust to neutral flame

7. Assume comfortable position

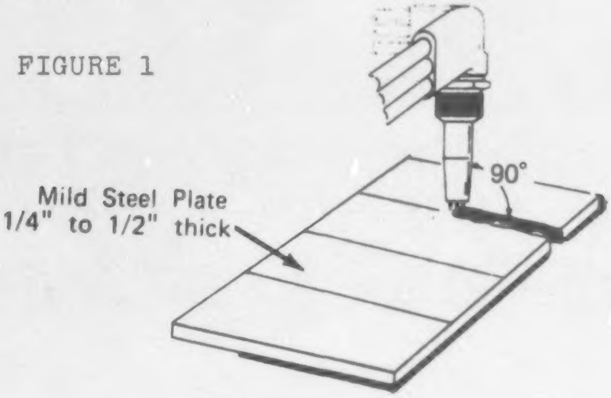
8. Place hoses behind operator

9. Maneuver torch with both hands

10. Hold preheat flame with tip of inner cone 1/16" to 1/8" above top of plate at right edge until red spot appears

11. Depress the oxygen cutting lever, and move from right to left across the plate (for left-handed operators, go from left to right) (Figure 1)

FIGURE 1



12. Hold the tip at right angles to work while cutting with inner cone being 1/16" to 1/8" above work

13. Make 90° cuts until you have developed the proper procedure

14. Cool metal by placing in can of water with the aid of pliers

15. Have instructor inspect

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT II

JOB SHEET #4--CUT A HOLE IN MILD STEEL

I. Tools and materials

   A. Cutting outfit with tip

   B. Mild steel plates

   C. Soapstone with a sharp point or edge

   D. Straight edge

   E. Gloves

   F. Welding goggles with #4 lens

   G. Pliers

   H. Protective clothing

   I. Striker

   J. Welding or cutting table

   K. Slag box

   L. Can of water

II. Procedure

   A. Draw two circles on metal

      1. Draw one circle 1" in diameter, 1" from edge

      2. Draw the other circle 1/2" in diameter, 1" from edge

   B. Adjust oxygen regulator

   C. Adjust acetylene regulator

   D. Place metal to be cut over slag box

   E. Light torch

   F. Adjust to neutral flame

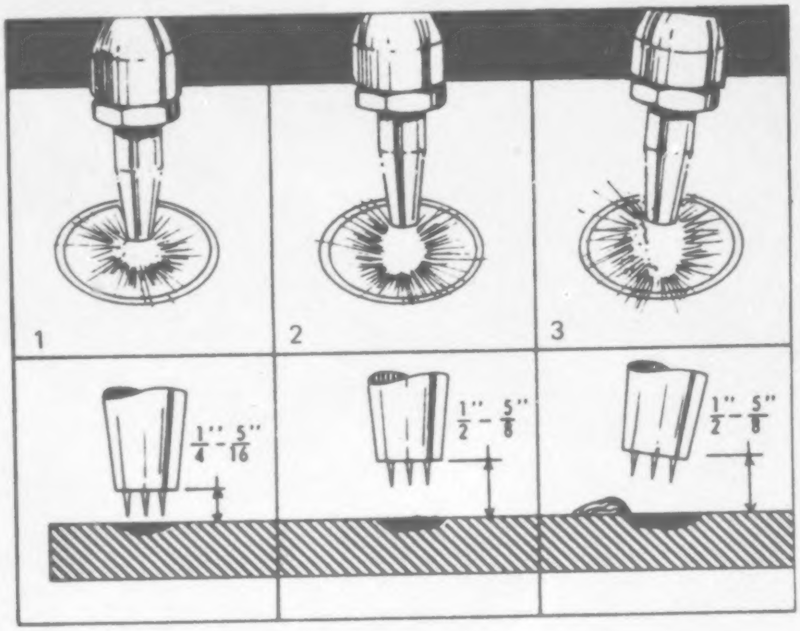
   G. Assume comfortable position

H. Place hoses behind operator

I. Maneuver torch with both hands

J. Hold tip of inner cone 1/16" to 1/8" above point to be cut until metal turns bright red (Figure 1)

FIGURE 1



1. Tilt torch 15° from vertical position

   (NOTE: This will allow molten metal to be blown away from operator.)

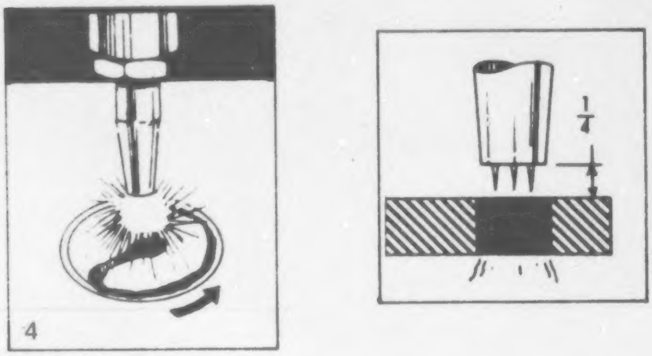
2. Depress oxygen cutting lever slowly moving torch backwards (to the operator's right if right handed) until cut pierces plate

K. Return cutting torch to vertical position

1. Raise cutting tip until tip of inner cone is from 1/4" to 1/2" above the plate

2. Make cut (Figure 2)

FIGURE 2



L. Cut just inside soapstone mark until circular cut is completed

M. Repeat steps K and L until all holes are cut

N. Turn off oxyacetylene rig

O. Cool metal by placing in can of water with the aid of pliers

P. Have instructor inspect

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT II

JOB SHEET #5--LAY BEADS ON GAUGE METAL WITHOUT FILLER ROD

I. Tools and materials

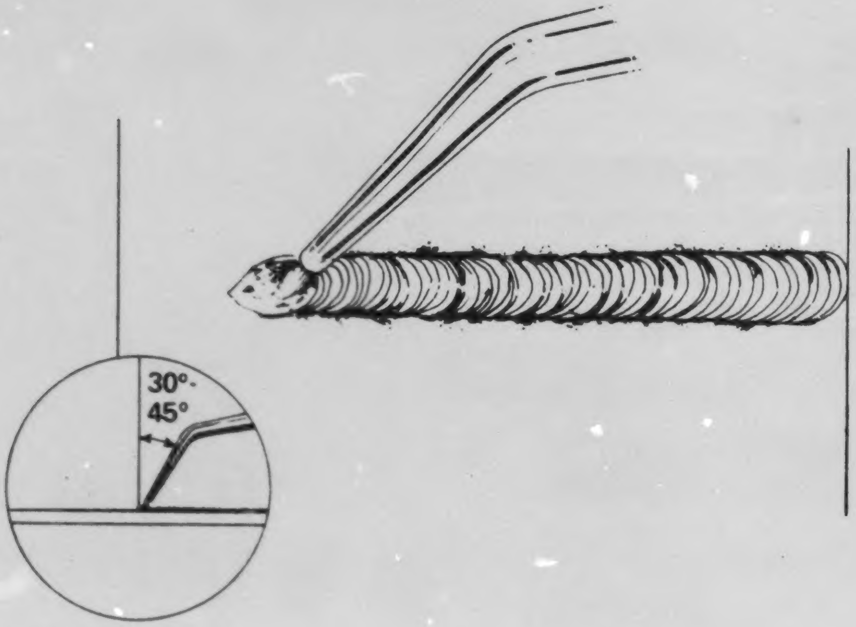
- A. Oxyacetylene welding unit
- B. Welding tip #8
- C. Gloves
- D. Welding goggles with #6 lens
- E. Pliers
- F. Wire brush
- G. Striker
- H. Fire brick
- I. One piece of 16 gauge mild steel, 1 1/4" x 6"

II. Procedure

- A. Prepare metal for welding
- B. Place metal in welding position
- C. Turn on oxyacetylene unit
- D. Set working pressure
- E. Light torch and adjust to a neutral flame
- F. Place inner cone about 1/16" to 1/8" from metal
- G. Do not begin travel until you have established a molten puddle

H. Hold torch 30° to 45° from center in direction of travel (Figure 1)

FIGURE 1



I. Slowly move the torch forward allowing the metal to melt

J. Repeat process until instructor gives permission to go on to next job

(NOTE: Always turn off oxyacetylene rig when not using it.)

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT II

JOB SHEET #6--LAY BEADS ON GAUGE METAL WITH FILLER ROD

I. Tools and materials

   A. Oxyacetylene welding unit

   B. Welding tip (according to manufacturer's recommendations)

   C. Gloves

   D. Welding goggles with #6 lens

   E. Pliers

   F. Wire brush

   G. Striker

   H. Fire brick

   I. One piece of mild steel strip, 16 gauge 1 1/4" by 6"

   J. Filler rod mild steel (according to manufacturer's recommendations)

II. Procedure

   A. Prepare metal for welding

   B. Place metal in welding position

   C. Turn on oxyacetylene unit

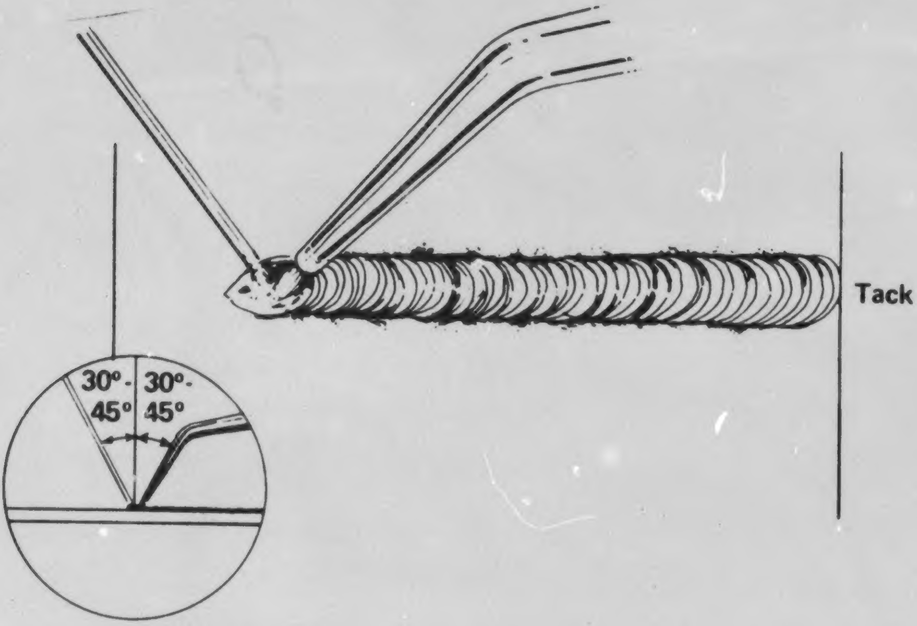
   D. Set working pressure

   E. Light torch and adjust to a neutral flame

   F. Hold torch 30° to 45° from center

G. Place inner cone about 1/16" to 1/8" from surface of puddle (Figure 1)

FIGURE 1



H. Do not begin travel until you have established a molten puddle

I. Add filler rod to front edge of puddle in front of torch

J. Move puddle forward with torch and allow puddle to form in base metal

K. Add rod and withdraw rod to front edge of puddle as you move puddle forward

L. Keep puddle the same size and shape the entire length of the bead

M. Turn off oxyacetylene rig

N. Have instructor inspect

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT II

JOB SHEET #7--WELD BUTT JOINTS WITH FILLER ROD

I. Tools and materials

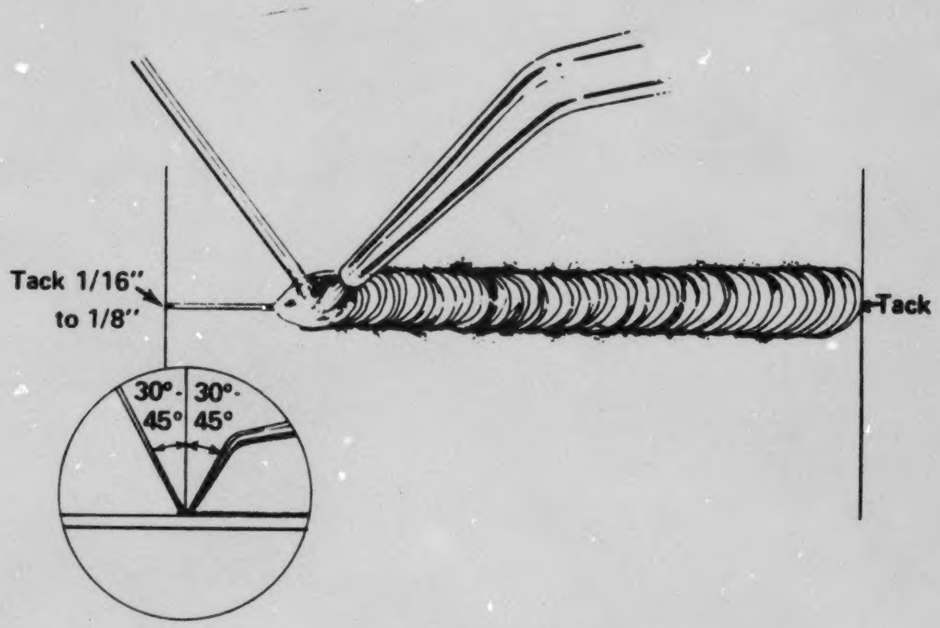
- A. Oxyacetylene welding unit
- B. Welding tip (according to manufacturer's recommendations)
- C. Gloves
- D. Welding goggles with #6 lens
- E. Pliers
- F. Wire brush
- G. Striker
- H. Fire brick
- I. Two pieces of mild steel strips, 16 gauge 1 1/4" by 6"
- J. Filler rod mild steel (according to manufacturer's recommendations)

II. Procedure

- A. Prepare metal for welding
- B. Place metal in welding position
- C. Turn on oxyacetylene unit
- D. Set working pressure
- E. Light torch and adjust to a neutral flame
- F. Tack weld metal together at both ends of joint
- G. Hold torch 30° to 45° from center
- H. Do not begin travel until you have established a molten puddle

I. Place inner cone about 1/16" to 1/8" from surface of puddle (Figure 1)

FIGURE 1



J. Add filler rod to front edge of puddle in front of torch

K. Move puddle forward with torch and allow puddle to form in base metal

L. Add rod and withdraw rod to front edge of puddle as you move puddle forward

M. Keep puddle the same size, shape, and centered the entire length of the bead

N. Turn off oxyacetylene rig

O. Show bead to instructor when completed

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT II

JOB SHEET #8--BRAZE WELD A SQUARE GROOVE BUTT JOINT

I. Tools and materials

- A. Oxyacetylene welding unit
- B. Gloves
- C. Colored safety glasses
- D. Welding goggles with #4 lens
- E. Welding tip (according to manufacturer's recommendations)
- F. Wire brush
- G. Striker
- H. Fire brick
- I. Two pieces of clean mild steel strips, 1/8" thick, 1 1/4" by 6"
- J. Bronze filler rod (use according to manufacturer's recommendations)
- K. Welding flux

II. Procedure

- A. Prepare metal for brazing--clean
- B. Place metal in brazing position--1/16" to 1/8" apart
- C. Turn on oxyacetylene unit
- D. Adjust proper working pressure of oxygen and acetylene
- E. Place metal on fire brick

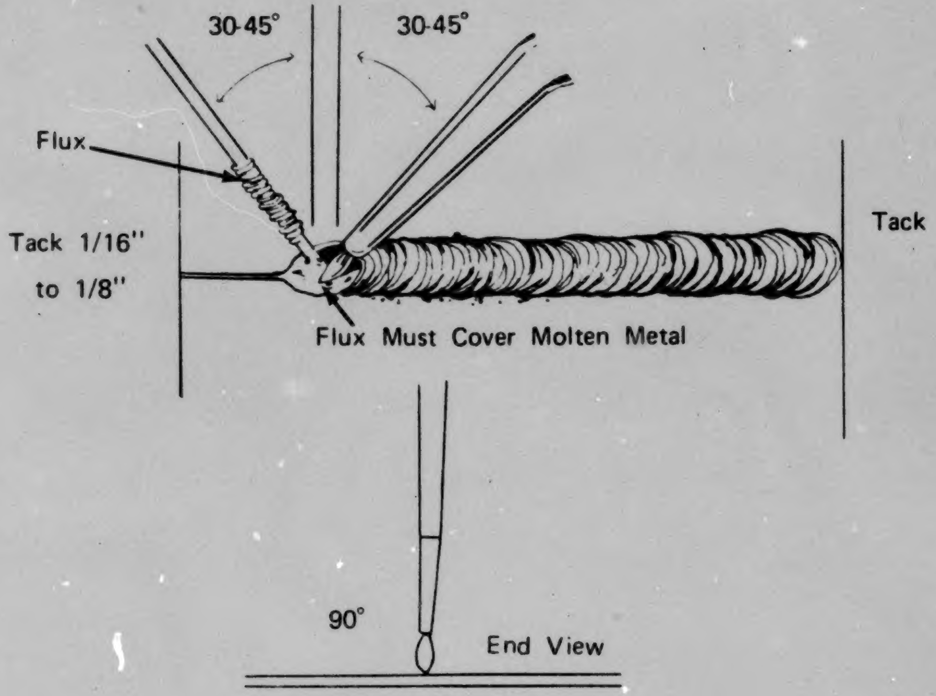
  (NOTE: Do not lay metal flat on brick. Arrange metal so a small space will be between the base metal and the fire brick.)
- F. Light and adjust torch to a neutral or slightly oxidized flame
- G. Preheat the end of the brazing rod and dip in the flux or use fluxed rod

H. Tack metal in place using braze filler metal

I. Heat the surface of the weld area slightly

J. Hold torch 30° to 45° from vertical; hold filler rod at the same angle in opposite direction (Figure 1)

FIGURE 1



K. Melt a small amount of bronze rod onto the surface and allow it to spread along the entire seam when a dull cherry-red color occurs

L. When the base metal is tinned sufficiently, start depositing the proper size bead

M. Watch for base metal color

(NOTE: When metal is not hot enough, the bronze will form into drops; when metal is too hot, bronze tends to boil. This is indicated by excessive white smoke.)

N. Turn off oxyacetylene rig

O. Inspect weld then check with instructor

S-65-E

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT II

NAME________________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Chemical used to clean metals and to promote fusion during the welding process

_____b. Melting a small amount of bronze rod onto the surface and allowing it to spread along the entire seam (joint)

_____c. Joining pieces of metal by heating the adjoining edges to the fusion or melting point and allowing them to flow or run together and then cool

_____d. Momentary burning back of the flame into the tip

_____e. Process by which iron or steel is heated to a temperature where it can be rapidly oxidized by high purity oxygen flowing under pressure through a cutting torch

_____f. Inner white part of the neutral flame

_____g. Short weld used for temporrarily holding material in place

_____h. Term usually applied to rust, corrosion, coating, film, or scale

_____i. Heating the base metal to a dull red color and depositing a bead over the seam (joint) with a bronze filler rod; the base metal is not melted

1. Backfire
2. Flame cutting
3. Oxide
4. Base metal
5. Malleability
6. Flux
7. Tack weld
8. Tinning operation
9. Penetration
10. Fusion welding
11. Braze welding
12. Inner core
13. Puddle

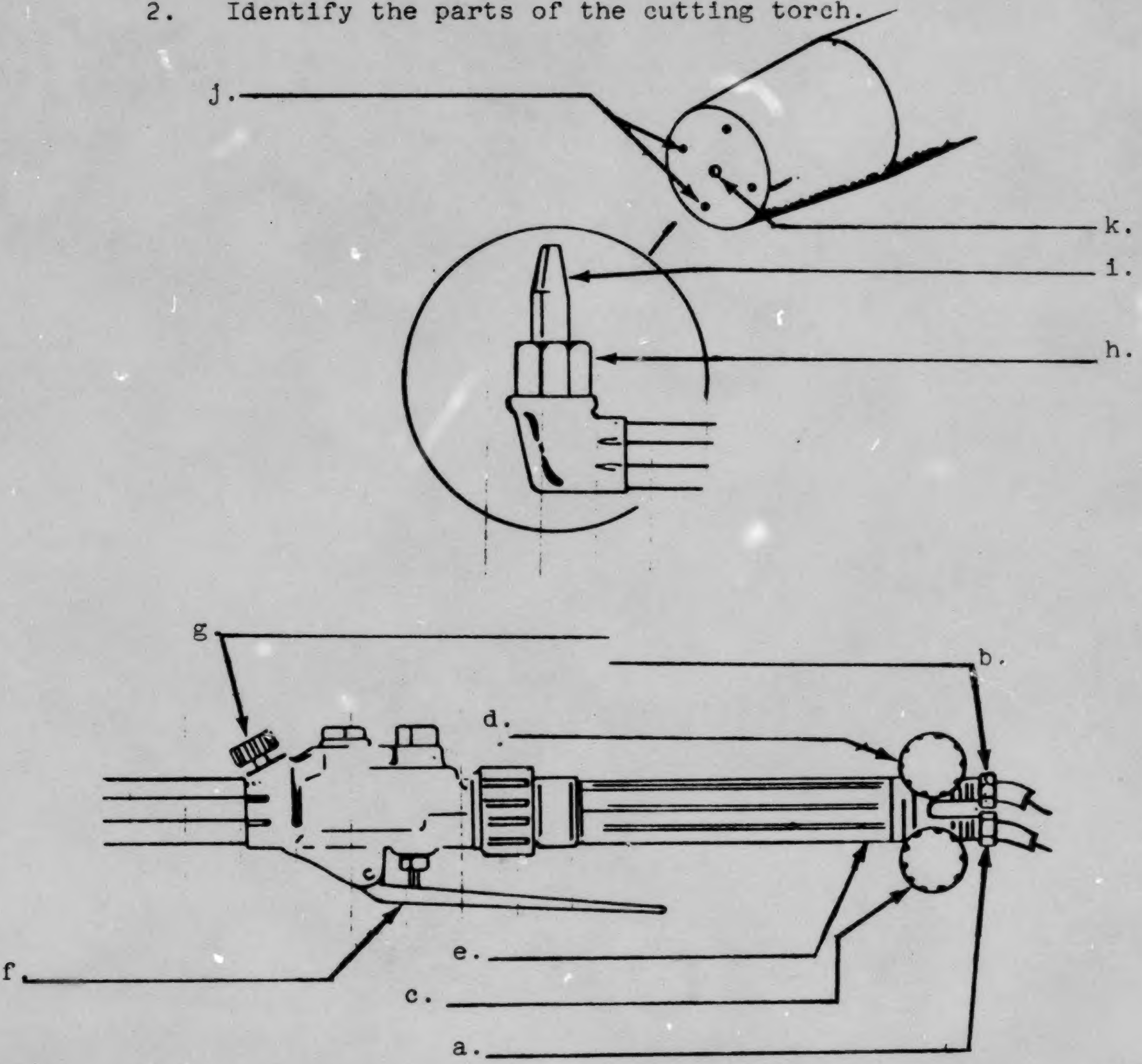
_____j. That portion of a weld that is molten at the place the heat is supplied

_____k. Property of metals which allows them to be bent or permanently distorted without rupture; opposite of brittleness

_____l. Distance from the original surface of the base metal to the point at which fusion ceases

_____m. Metal being welded

2. Identify the parts of the cutting torch.



3. Describe the results of a flashback.

A. ____________________

B. ____________________

  1. ____________________

  2. ____________________

  3. ____________________

4. List in the proper order the steps to follow in case of a flashback.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________

h. ____________________

5. Name five factors that determine fusion weld quality.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

6. List four properties of a good weld.

a. __________ c. __________

b. __________ d. __________

7. Name two factors that determine tip size selection in oxyacetylene fusion welding.

a. ____________________

b. ____________________

8. List two factors that determine the filler rod selection in oxyacetylene fusion welding.

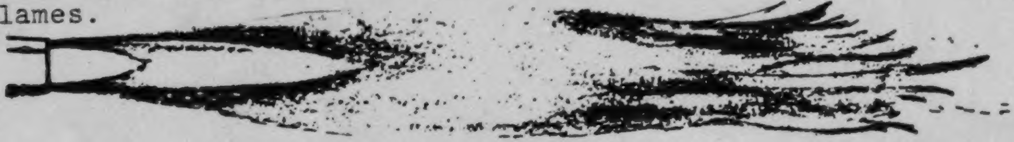
a. ______________________________

b. ______________________________

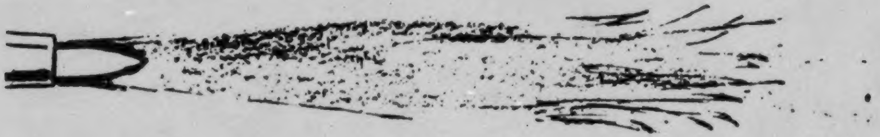
9. State the purpose of the filler rod. ______________________________

____

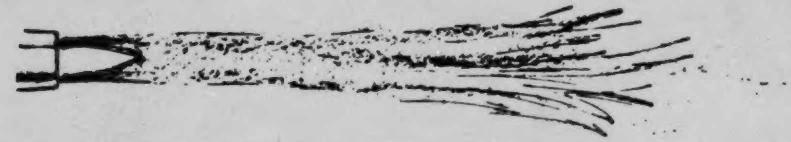
10. Identify three types of oxyacetylene fusion welding flames.



a. ____________________



b. ____________________



c. ____________________

11. List two advantages of braze welding.

a. ______________________________

b. ______________________________

12. List three disadvantages of braze welding.

a. ______________________________

b. ______________________________

c. ______________________________

13. Match the characteristics of the elements found in the filler rods used in braze welding to the appropriate element.

a. Copper

1. _____

2. _____

a. Deoxydize the weld metal

b. Increase ductility

c. Increase the free flowing action of the molten metal

b. Tin, iron, manganese, and silicon

1. _____

2. _____

3. _____

4. _____

d. Decrease the tendency to fume

e. Produce a high tensile strength

f. Increase the hardness of the deposited metal for greater wear resistance

14. Name two reasons for having a chemically clean metal surface in braze welding.

a.____

b.____

15. Name two methods for removing oxides from a clean metal surface.

a.____

b.____

16. List three purposes of flux.

a.____

b.____

c.____

17. Match the reaction of molten bronze to the appropriate base metal temperature that brings about the reaction.

a._____Not hot enough

b._____Medium

c._____Too hot

1. The molten bronze will tend to boil and to form little balls

2. The molten bronze will not flow over the surface but will form into drops

3. The molten bronze will spread out evenly and flow over a considerable area

18. Select from the list the proper tip size, oxygen pressure, and acetylene pressure for weld 3/8" steel.

Tip Size	Oxygen Pressure	Acetylene Pressure	Metal Thickness
000	1/2-2	1/2-2	Up to 1/32"
00	1-2	1-2	1/64" to 3/64"
0	1-3	1-3	1/32" to 5/65"
1	1-4	1-4	3/64" to 3/32"
2	2-5	2-5	1/16" to 1/8"
3	3-7	3-7	1/8" to 3/16"
4	4-10	4-10	3/16" to 1/4"
5	5-12	5-15	1/4" to 1/2"
6	6-14	6-15	1/2" to 3/4"
7	7-16	7-15	3/4" to 1 1/4"
8	9-19	8-15	1 1/4" to 2"
9	10-20	9-15	2" to 2 1/2"
10	11-22	10-15	2 1/2" to 3"
11	13-24	11-15	3" to 3 1/2"
12	14-28	12-15	3 1/2" to 4"

19. State an acceptable lens shade number for oxyacetylene welding.

____

20. Demonstrate the ability to:

    a. Set up equipment for oxyacetylene cutting.

    b. Turn on, light, adjust to a neutral flame, and turn off the oxyacetylene cutting equipment.

    c. Make ninety degree cuts on mild steel and restart a cut.

    d. Cut a hole in mild steel.

    e. Lay beads on gauge metal without filler rod.

    f. Lay beads on gauge metal with filler rod.

    g. Weld butt joints with filler rod.

    h. Braze weld a square groove butt joint.

    (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT II

ANSWERS TO TEST

1.
   - a. 6
   - b. 8
   - c. 10
   - d. 1
   - e. 2
   - f. 12
   - g. 7
   - h. 3
   - i. 11
   - j. 13
   - k. 5
   - l. 9
   - m. 4

2.
   - a. Oxygen fitting
   - b. Acetylene fitting
   - c. Oxygen torch valve
   - d. Acetylene torch valve
   - e. Torch body
   - f. Oxygen cutting lever
   - g. Oxygen preheat valve
   - h. Tip nut
   - i. Slip-in tip
   - j. Preheat orifice
   - k. Cutting orifice

3. Description should include:
   - a. Fire inside torch
   - b. Disappearance of flame followed by:
     1. Squealing or hissing inside torch
     2. Sparks coming from torch
     3. Smoke coming from the torch

4. a. Close oxygen preheat valve
   b. Close oxygen torch valve
   c. Close acetylene torch valve
   d. Release oxygen regulator screw
   e. Release acetylene regulator screw
   f. Examine acetylene unit
   g. Reset regulator pressures
   h. Light torch

5. a. Proper flame adjustment
   b. Angle of tip
   c. Distance from work
   d. Speed of travel
   e. Movement of tip

6. Any four of the following:
   a. Consistent width
   b. Straightness
   c. Slightly crowned
   d. Fused into base metal
   e. Clean appearance

7. a. Metal thickness
   b. Size of welding rod

8. a. Rod with similar properties as base metal
   b. Thickness of metal

9. To add strength to weld or joint

10. a. Carburizing flame
    b. Neutral flame
    c. Oxidizing flame

11. Any two of the following:
    - a. Less possibility of destroying main characteristics of base metal
        - 1. Base metal does not have to be heated to a molten condition
            - a. This increases the speed of joining metals
            - b. Less gas is consumed for a given job
        - 2. In repairing malleable castings, there is less danger of its losing its ductile properties
    - b. The low degree of heat minimizes expansion and contraction forces
    - c. Less need for extensive preheating

12. Any three of the following:
    - a. Not recommended for parts which are to be raised to temperatures higher than the melting point of bronze, either in service or during heat treatment
    - b. Bronze will lose its strength at temperatures above 500°F
    - c. It cannot be used on metal where stress is a factor
    - d. Bronze may have corrosion resistant properties which differ from those of the base metal being used

13. a. Copper
    - 1. b
    - 2. e

    b. Tin, iron, manganese, and silicon
    - 1. a
    - 2. c
    - 3. d
    - 4. f

14. a. To guarantee the molten bronze will stick to the base metal

    b. To have a stronger bond on base metal

15. a. Mechanical--Wire brush or grinder

    b. Chemical--Flux

16. Any three of the following:

    a. Chemically cleans the base metal

    b. Prevents oxidation of the filler metal

    c. Floats and removes the oxides already present

    d. Increases the flow of the filler metal

    e. Increases the ability of the filler metal to adhere to the base metal

    f. Brings the filler metal into immediate contact with the metals being joined

    g. Permits the filler metal to penetrate the pores of the base metal

17. a. __2__ Not hot enough

    b. __3__ Medium

    c. __1__ Too hot

18. Tip size - 5

    Oxygen Pressure - 5-12

    Acetylene Pressure - 5-15

19. 4 or 5

20. Performance skills evaluated to the satisfaction of the instructor.

ELECTRIC WELDING
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to name the types of arc welding machines and electrodes. The student should be able to do a vertical butt and "T" or fillet weld with the electric welder. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with electric welding to the correct definitions.
2. Name two types of arc welding machines.
3. Distinguish between straight and reverse polarity.
4. Name the two types of operating adjustments found on arc welding machines.
5. Name two types of electrodes.
6. Name two common sizes of electrodes.
7. Select the statement which determines electrode size.
8. Select the purposes of flux coating on electrodes.
9. Identify the numbers in the AWS electrode code classification.
10. Name four factors to be considered when selecting an electrode for a specific job application.
11. Identify the parts of the welding process.
12. Name two methods of striking an arc.
13. State the correct range of lens shade number for electric welding.
14. List two reasons for removing slag from weld.

15. Name two reasons for fusing one bead in with another.

16. List six reasons for improperly formed beads.

17. Demonstrate the ability to:

    a. Start, stop, and restart a bead.

    b. Make a pad in the flat position.

    c. Make a square groove butt weld.

    d. Make a multiple pass T-joint fillet weld.

ELECTRIC WELDING
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet.
- B. Provide student with information and job sheets.
- C. Make transparencies.
- D. Discuss unit and specific objectives.
- E. Discuss information sheet.
- F. Demonstrate and discuss the procedures outlined in the job sheets.
- G. Give test.

II. Student:

- A. Read objective sheet.
- B. Study information sheet.
- C. Complete job sheets.
- D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Transparency masters
    1. TM 1--Welding Circuit
    2. TM 2--Welding Characteristics and Operating Data of Mild Steel Electrodes
    3. TM 3--Standardized AWS Classification
    4. TM 4--Parts of the Welding Process
    5. TM 5--Improperly Formed Beads

D. Job Sheets

1. Job Sheet #1--Start, Stop, and Restart a Bead
2. Job Sheet #2--Make a Pad in the Flat Position
3. Job Sheet #3--Make a Square Groove Butt Weld
4. Job Sheet #4--Make a Multiple Pass T-Joint Fillet Weld

E. Test

F. Answers to test

II. References:

A. Sosnin, H. A. Arc Welding Instructions for the Beginner. Cleveland, Ohio: The James F. Lincoln Arc Welding Foundation, 1973.

B. Welding Curriculum. Stillwater, Oklahoma: State Department of Vocational and Technical Education, 1974.

ELECTRIC WELDING
UNIT III

INFORMATION SHEET

I. Terms and definitions

   A. Shielded metal arc welding--Arc welding process wherein metals are united by heating with an electric arc between a coated metal electrode and the metal

   B. Base metal--Metal to be welded or cut

   C. Arc length--Distance from the end of the electrode to the point where the arc makes contact with work surface

   D. Face of weld--Exposed surface of a weld, made by an arc or gas welding process, on the side from which welding was done

   E. Flux--Fusible material or gas used to dissolve and/or prevent the formation of oxides, nitrides, or other undesirable inclusions formed in welding

   F. Pass--Single longitudinal progression of a welding operation along a joint or weld deposit

   G. Spatter--Metal particles given off during welding which do not form a part of the weld

   H. Tack weld--Weld made to hold parts in proper alignment until the final welds are made

   (NOTE: This type of welding is for assembly purpose only.)

   I. Puddle--That portion of a weld that is molten at the place the heat is supplied

   J. Weld metal--That portion of a weld which has been melted during welding

   K. AWS--American Welding Society

II. Types of arc welding machines

   A. AC (alternating current) transformer welder--Current alternating direction 120 times per second

B. AC-DC transformer rectifier--Provides either alternating current or direct current

III. Types of polarity (Transparency 1)

A. Reverse--Current flows base metal to electrode

B. Straight--Current flows from electrode to base metal

(NOTE: Welding leads must connect to correct terminals if machine has a polarity switch. Otherwise a change in polarity is made by reversing leads on the terminals.)

IV. Types of operating machine adjustments (Transparency 1)

A. Current (amperage) settings

(NOTE: Increasing amps produces more heat and decreasing amps produces less heat.)

B. Polarity

V. Types of electrodes (Transparency 2)

A. Mild steel

B. Stainless steel

VI. Common electrode sizes

(NOTE: Electrodes range in size from 1/16" to 5/16".)

A. 3/32"

B. 1/8"

VII. Determining electrode size--Determined by diameter of bare end of electrode

VIII. Purposes of flux coating on electrodes

A. Stabilizes arc

B. Shields molten puddle from air

C. Floats impurities out of puddle

D. Forms slag and slows cooling

E. Provides deoxidizers and scavengers to prevent porosity of weld zone

F. Provides alloying elements for higher strength welds

- G. Provides iron powder to increase the disposition rate

IX. Numbers in the AWS electrode classification (Transparency 3)

- A. E--Stands for electrode
- B. First two digits--Indicate tensile strength deposited in a thousand pounds per square inch
- C. Third number--Indicates welding position
  - 1. All positions
  - 2. Flat and horizontal
- D. Fourth digits--Represents special characteristics and usability of the rod
  - 1. Current
  - 2. Penetration
  - 3. Type of flux coating

X. Factors for selecting electrodes for a specific job application

- A. Base metal strength properties
- B. Base metal composition
- C. Welding position
- D. Welding current
- E. Joint design and fit-up
- F. Thickness and shape of base metal

XI. Parts of welding process (Transparency 4)

- A. Slag
- B. Weld
- C. Electrode
- D. Wire core
- E. Coating
- F. Arc

G. Crater

H. Penetration

I. Base metal

J. Heat lines

K. Gaseous shield

L. Ten degrees--fifteen degrees

XII. Methods of striking an arc

A. Tapping

B. Scratching

XIII. Safety lens range for electric welding--9-14

(NOTE: A safety lens within the 9 to 14 range will be adequate for all types of electric welding.)

XIV. Reasons for removing slag from a weld

A. Permits better fusion of beads

B. Prevents gas pockets and slag inclusions from forming in bead

C. Improves appearance of bead

XV. Reasons for fusing one bead in with another

A. Increases strength of weld

B. Improves appearance of bead

C. Improves penetration

XVI. Improperly formed beads (Transparency 5)

A. Improperly (poorly) formed beads may be caused by:

1. Current adjusted too high

2. Current adjusted too low

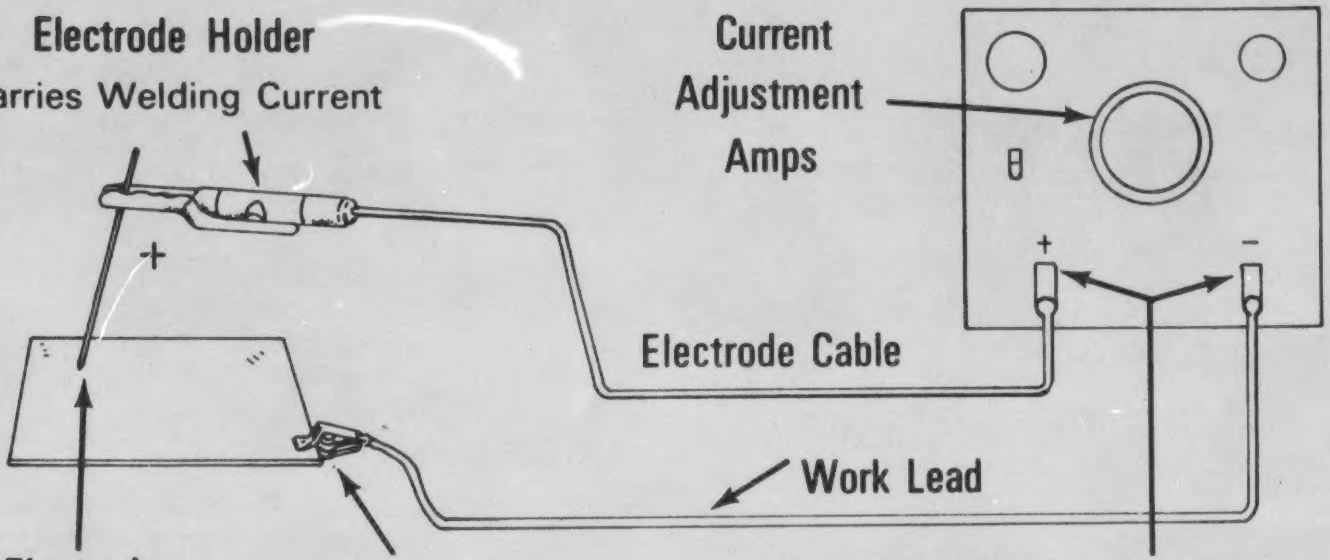
3. Voltage adjusted too high

4. Voltage adjusted too low

5. Speed too slow

6. Speed too high
7. Improper electrode or size
8. Improper arc length
9. Improper angle of electrode
10. Improper preparation of base metal

Welding Circuit



Welding Machine

Electrode Holder

Carries Welding Current

Current Adjustment Amps

Electrode Cable

Work Lead

Electrode

Diameters:
1/16 - 5/16 x 14′
Most Common
Length

Ground Clamp

Completes
Welding Circuit

Polarity-D.C. Current

Reverse:

1. Electrode (+)
2. Current flows from work to electrode
3. 2/3 heat at (+) electrode
   1/3 heat at (-) work

Straight:

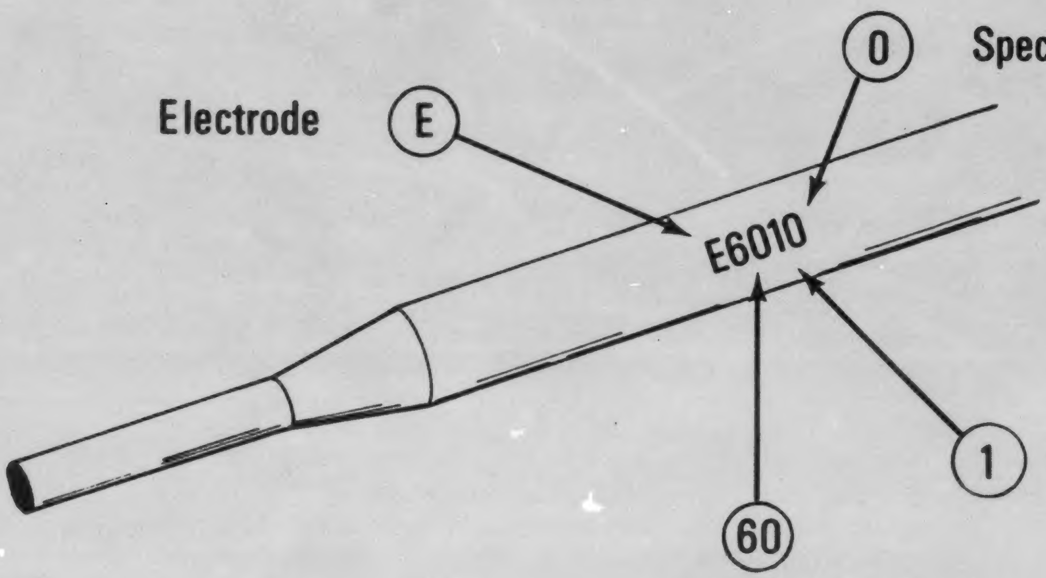
1. Electrode (-)
2. Current flows from electrode to work
3. 2/3 heat at (-) work
   1/3 heat at (+) electrode

WELDING CHARACHTERISTICS AND OPERATING DATA OF MILD STEEL ELECTRODES

	Coating Color	Position of Welding	Type of Current* Used	Penetration	Rate of Deposition	Appearance of Bead	Minimum Tensile Strength	3/32" Size	1/8" Size	5/32" Size	3/16" Size
E6010	White	All Positions	DC, Reverse (+)	Deep	Av. Rate	Rippled and Flat	62,000psi		75-130	90-175	140-225
E6011	White	All Positions	AC DC, Reverse (+)	Deep	Av. Rate	Rippled and Flat	62,000psi		75-120 70-110	90-160 80-145	120-200 110-180
E6012	Tan	All Positions	DC,Str. AC (-)	Medium	Good Rate	Smooth and Convex	67,000psi	55-80 60-90	80-135 90-150	110-180 120-200	155-250 170-275
E6013	Dark Tan	All Positions	AC DC, Str. (-) or Reverse	Mild	Good Rate	Smooth, Flat, and Convex	67,000psi	65-100 60-90	90-140 80-125	140-200 125-180	200-260 180-235

*DC Reverse means DC, reverse polarity (electrode positive).
DC Straight means DC, straight polarity (electrode negative).

Standardized AWS Classification



Electrode E

0 Special Characteristics

current
penetration
type of flux
coating

1 Welding Positions

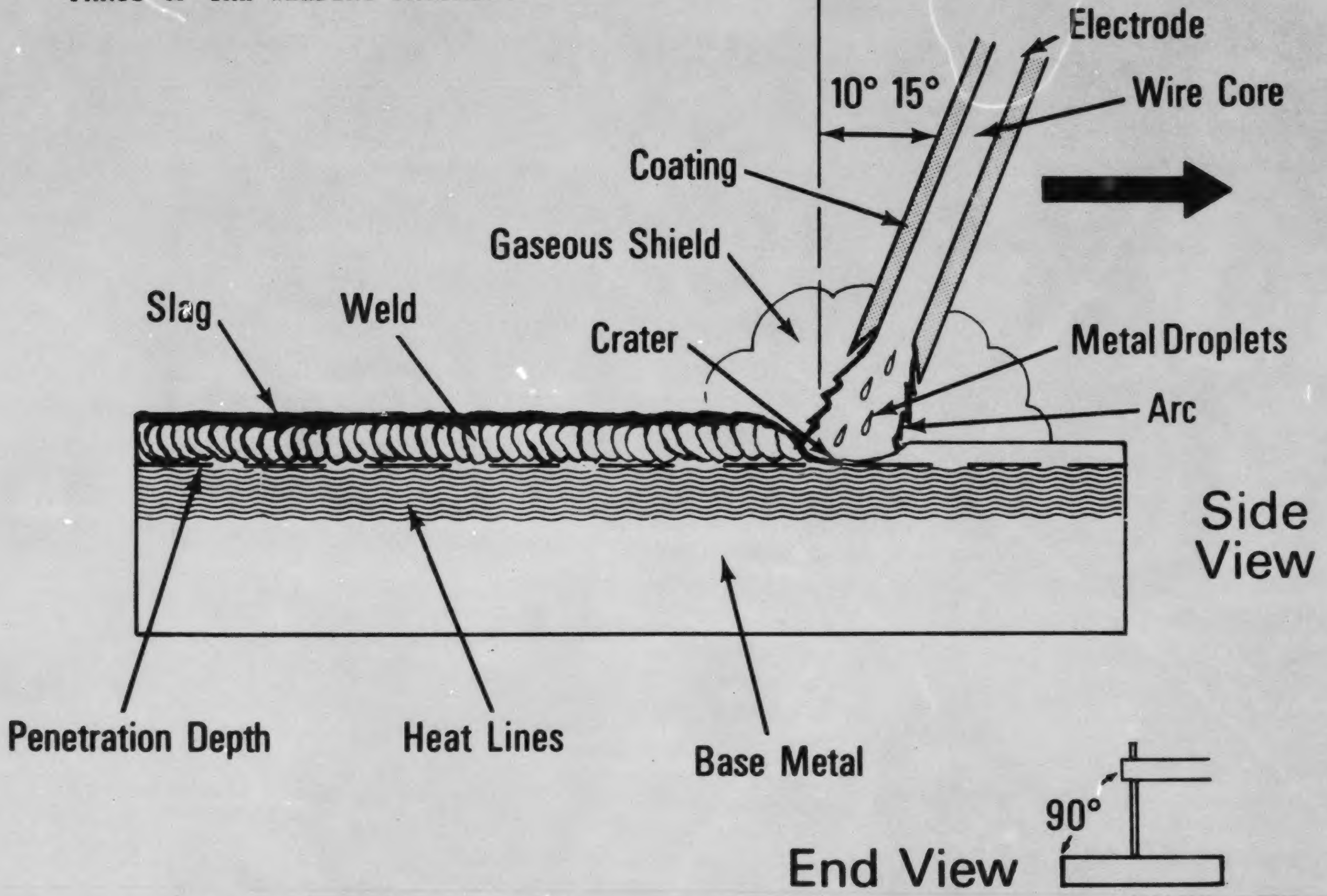
1. all positions
2. flat and horizontal

60

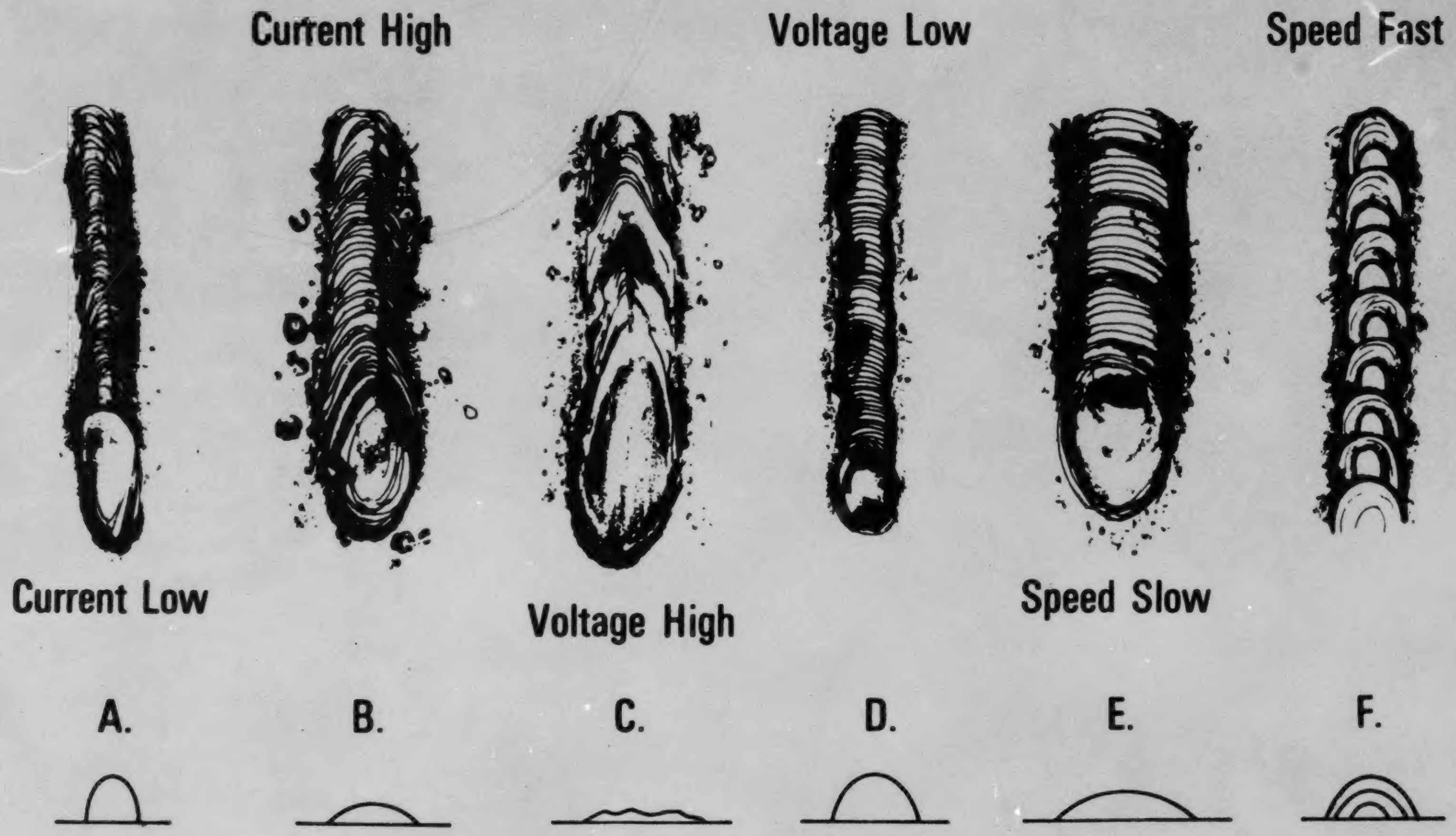
Tensile Strength 1,000 Lbs. Per Sq. Inch

E6010 Mild Steel Electrode

PARTS OF THE WELDING PROCESS



Improperly Formed Beads



ELECTRIC WELDING
UNIT III

JOB SHEET #1--START, STOP, AND RESTART A BEAD

I. Tools and materials

- A. Welding machine and accessories
- B. Welding helmet
- C. Protective clothing
- D. Chipping hammer
- E. Safety glasses with side screens
- F. Wire brush
- G. Pliers for handling hot metal
- H. Metal

  (NOTE: Size and thickness of metal will be selected by the instructor.)

- I. Welding electrode

  (NOTE: Type and size of electrode will be selected by the instructor.)

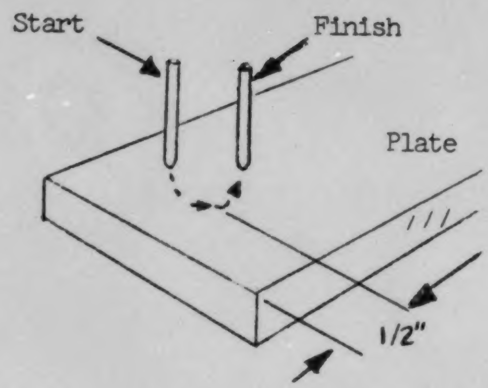
II. Procedure

- A. Start the bead
  1. Adjust machine to desired welding current

     (NOTE: This desired current will depend on type and size of electrode, and thickness of metal. Refer to Chart #1.)

  2. Hold electrode perpendicular to work where weld is to start (Figure 1)

FIGURE 1



3. Slant electrode 10° to 15° in direction of travel

4. Lower electrode and tap or scratch lightly on edge of plate

   (NOTE: This procedure is necessary for establishing an arc.)

5. Momentarily raise electrode upon establishment of arc.

   (NOTE: This preheats the edge of metal and prevents a cold start.)

6. Lower electrode to correct arc length

7. Rotate electrode

   (NOTE: Rotate the electrode to build up desired height of bead and to obtain desired width of bead. When desired crater develops, move out slowly using normal manipulation.)

B. Stop the bead

   1. Return electrode to 90° or perpendicular to work

   2. Reverse electrode and hold until crater fills

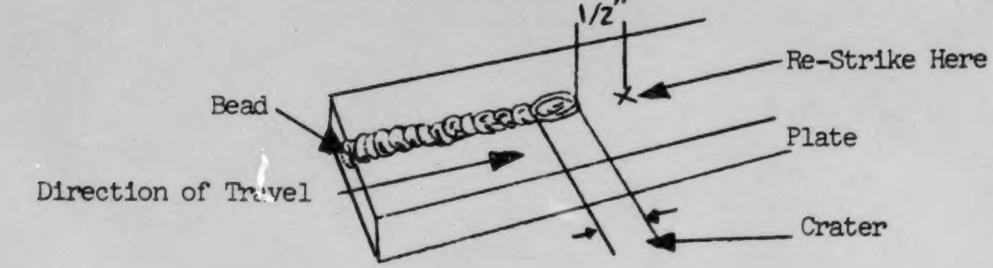
      (NOTE: This causes crater build up, removes impurities from weld, and prevents crater from cracking.)

   3. Raise electrode quickly when desired width and height of bead is formed

C. Restart the bead

   1. Start arc about 1/2" to 3/4" in front of crater

2. With a long arc, move electrode back to within 1/16" of the crater crown, fill to bead size, and then resume normal travel (Figure 2)



3. Fuse new crater into last ripple of crater

4. Maintain correct width of bead while completing weld

   (NOTE: Arc length is correct when it makes a "frying" noise. The force of the arc determines penetration and bead appearance.)

D. Continue practice until the instructor is satisfied with progress.

ELECTRIC WELDING
UNIT III

JOB SHEET #2--MAKE A PAD IN THE FLAT POSITION

I. Tools and materials

A. Welding machine and accessories

B. Welding helmet

C. Protective clothing

D. Chipping hammer

E. Wire brush

F. Pliers

G. Mild steel metal

(NOTE: Size and thickness will be selected by the instructor.)

H. Electrodes

(NOTE: The electrode type and size will be selected by the instructor.)

II. Procedure

A. Prepare and place metal in flat position

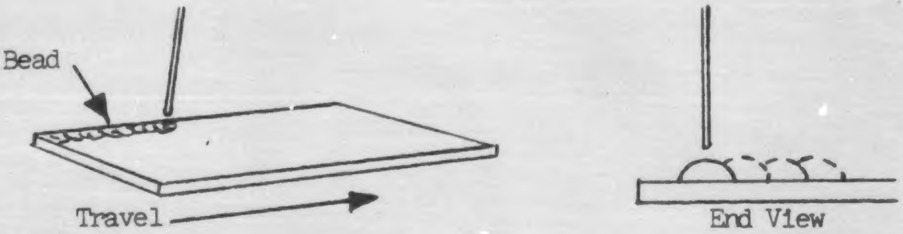
(NOTE: Remove rust, dirt, and mill scale from surface of metal.)

B. Adjust welding machine to desired welding current

(NOTE: The desired current will depend on type and size of electrode, and thickness of metal. Refer to chart #1.)

C. Run a straight bead near edge of plate (Figure 1)

FIGURE 1



(NOTE: For the first bead, the electrode should be held almost vertical. Do not use side angle.)

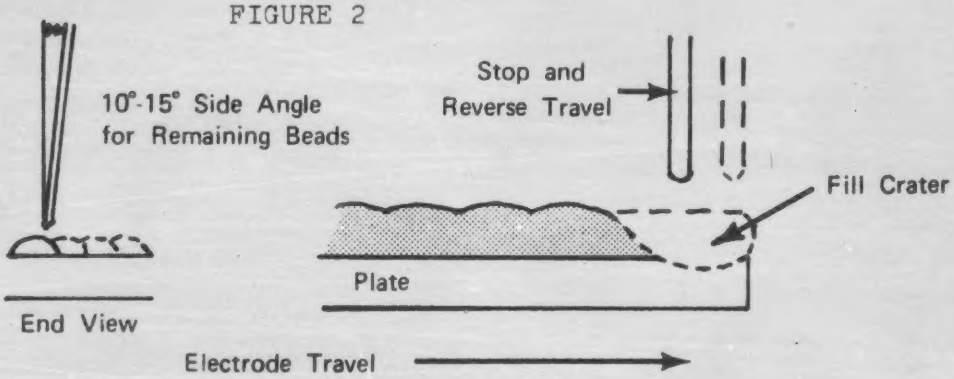
(CAUTION: Avoid burning off edge of plate.)

D. After laying first bead, chip and brush it clean and check surface

(NOTE: The surface appearance should be smooth and even. Check for pinholes, crater holes, slag holes, or indications of improper starts and stops. Also, checking the bead will identify if current needs to be changed.)

E. Reverse travel and run additional beads, remember to overlap at least the first one-third of the previous bead (Figure 2)

FIGURE 2



(NOTE: The electrode should be held at 10° to 15° to the side for this bead and all other beads.)

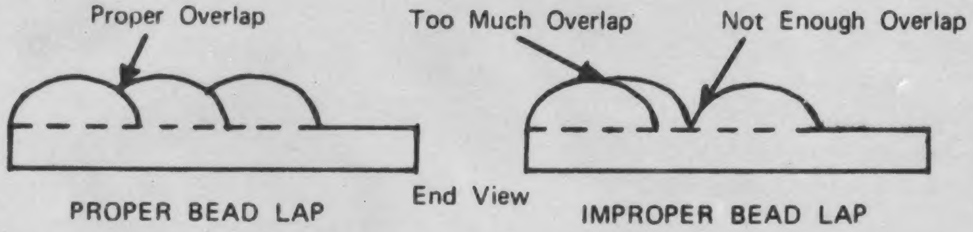
F. Clean each pass thoroughly before overlapping with another

(NOTE: This will insure a sound deposit with proper penetration and no slag holes.)

G. Fuse each pass with base metal as well as with the preceding pass (Figure 3)

(NOTE: Alternate travel direction for each pass.)

FIGURE 3



(NOTE: The overlapping beads should produce a comparatively smooth surface without noticeable "valleys" between passes.)

H. Continue running beads until pad is full

I. Clean the piece of metal thoroughly and have instructor inspect

ELECTRIC WELDING
UNIT III

JOB SHEET #3--MAKE A SQUARE GROOVE BUTT WELD

I. Tools and materials

A. Welding machine and accessories

B. Welding helmet

C. Protective clothing

D. Safety glasses with side screens

E. Chipping hammer

F. Wire brush

G. Pliers

H. Metal--Two pieces 3/16" to 1/4" thick, 2" to 4" wide, and 8" long

I. Electrode

(NOTE: Type and size of electrode will be selected by the instructor.)

II. Procedure

A. Adjust welding machine to correct welding current

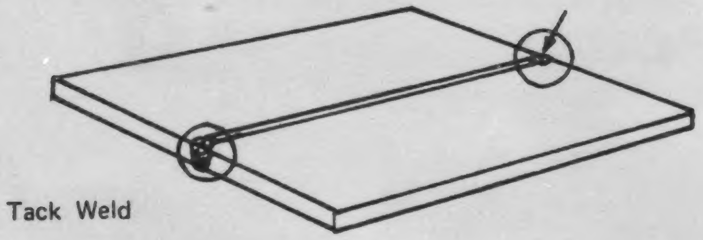
B. Prepare metal for welding by removing dirt, grease, or mill scale

C. Place metal together parallel to each other, leaving a space of 3/32"

(NOTE: The proper space can be determined by placing the bare end of a 3/32" electrode between the two pieces of metal.)

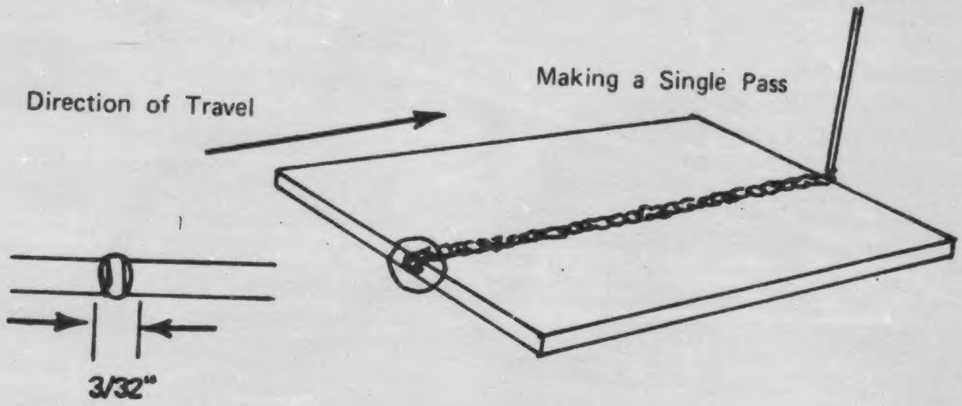
D. Tack weld pieces together at both ends (Figure 1)

FIGURE 1



E. Weld pieces together using a single pass on one side for 100% penetration (Figure 2)

FIGURE 2



F. Chip slag, brush weld, and check for complete penetration at the root of weld

G. Have the instructor inspect the weld.

ELECTRIC WELDING
UNIT III

JOB SHEET #4--MAKE A MULTIPLE PASS T-JOINT FILLET WELD

I. Tools and materials

   A. Welding machine and accessories

   B. Helmet

   C. Protective clothing

   D. Safety glasses with side screens

   E. Chipping hammer

   F. Wire brush

   G. Pliers

   H. Mild steel plates--two pieces 1/4" to 3/8" thick, 3" to 6" wide, and 8" long

   I. Electrodes

   (NOTE: The electrodes will be selected by the instructor.)

II. Procedure

   A. Adjust welding machine to correct current and amperage

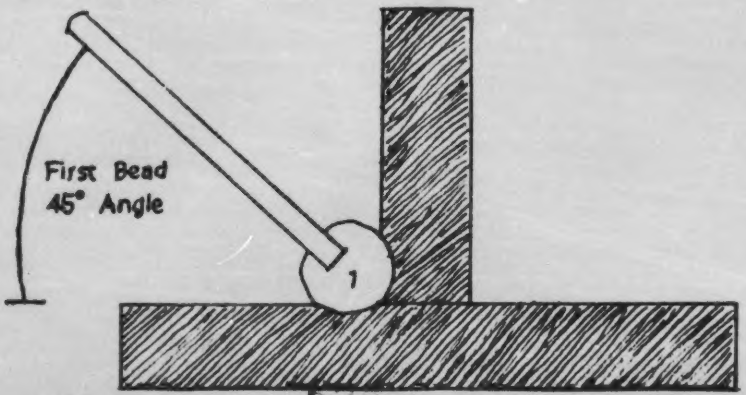
   B. Position plates on table to form a T-joint

   C. Tack plates on each end and remove slag

   D. For first bead, angle electrode 45° from vertical plate and 5°-10° in direction of travel (Figure 1)

FIGURE 1

Multiple Pass Fillet Weld



E. Strike arc at end of plate holding a high arc for 1 or 2 seconds

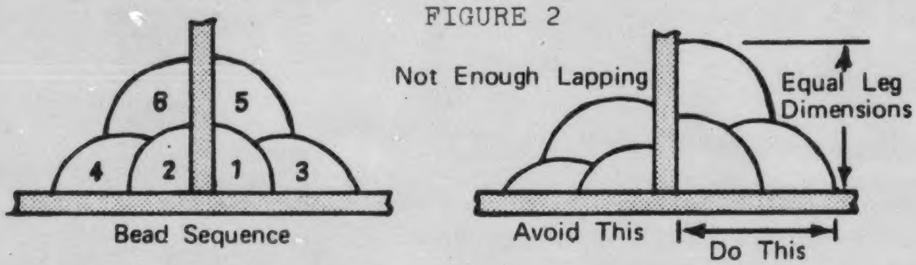
(NOTE: This allows for the end of the metal plates to heat prior to depositing the proper beads and prevents cold lap.)

F. Move electrode to opposite side of T-joint and start depositing second bead using same angle used in bead one

G. Deposit beads about two times wider than electrode diameter

(NOTE: Remember to alternate passes from one side to another of T-joint to minimize distortion of the plates. See Figure 2.)

FIGURE 2



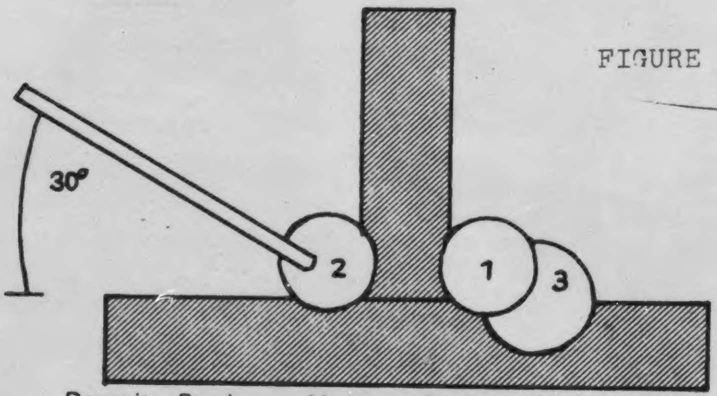
Keep Bead Dimensions Constant

H. Remove slag from bead one and two

(NOTE: Keep each bead dimension constant. It is necessary to overlap beads more than seems necessary to avoid laying too much on bottom by side of joint.)

I. Deposit bead three using a 30° angle from horizontal plate with the electrode slanting 5° to 10° in direction of travel (Figure 3)

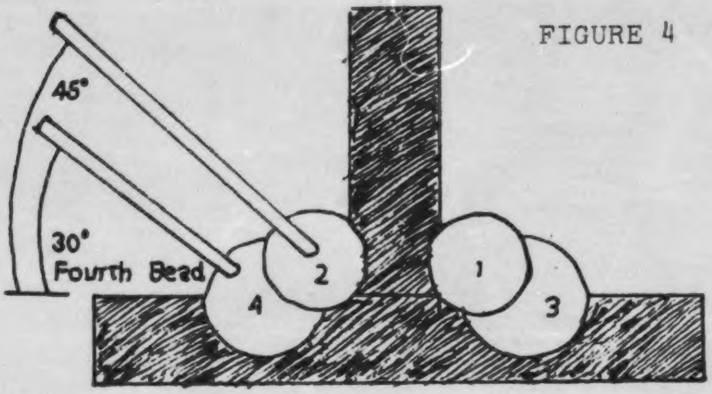
FIGURE 3



Deposit Beads on Alternate Sides to Minimize Distortion

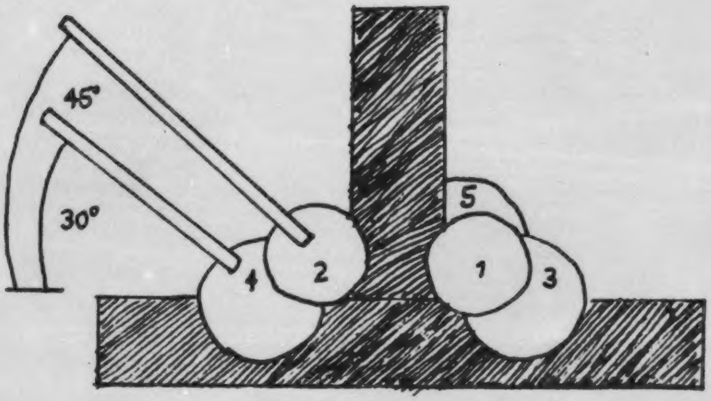
J. Deposit bead four using same angle as used in depositing bead three (Figure 4)

FIGURE 4



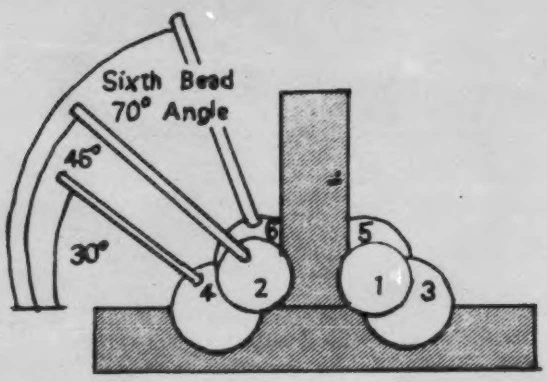
K. Deposit bead five using a 70° degree angle from vertical plate with the electrode slanting 5° to 10° in direction of travel (Figure 5)

FIGURE 5



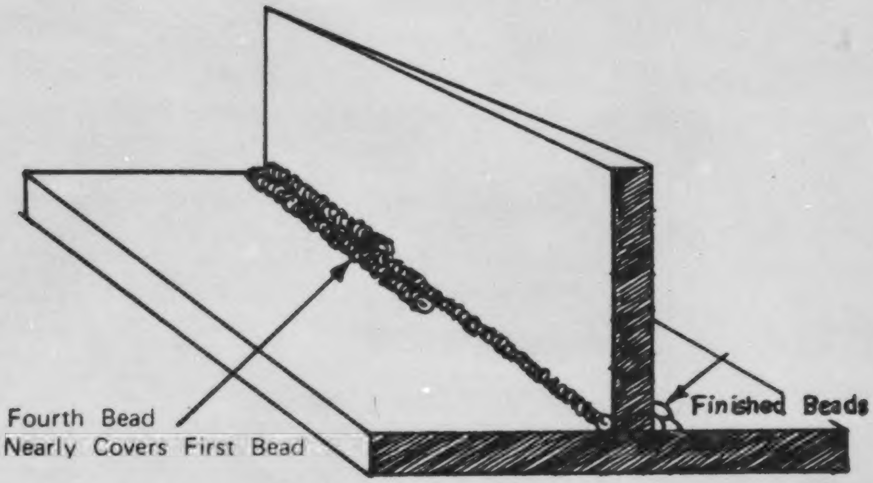
L. Deposit bead six using same angle as used in bead five (Figure 6)

FIGURE 6



M. After completing required number of passes, have instructor inspect (Figure 7)

FIGURE 7



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ELECTRIC WELDING
UNIT III

NAME______________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Arc welding process wherein metals are united by heating with an electric arc between a coated metal electrode and the metal

_____b. Distance from the end of the electrode to the point where the arc makes contact with work surface

_____c. Metal to be welded or cut

_____d. Fusible material or gas used to dissolve and/or prevent the formation of oxides, nitrides, or other undesirable inclusions formed in welding

_____e. That portion of a weld that is molten at the place the heat is supplied

_____f. Weld made to hold parts in proper alignment until the final welds are made

_____g. Metal particles given off during welding which do not form a part of the weld

_____h. Single longitudinal progression of a welding operation along a joint or weld deposit

_____i. That portion of a weld which has been melted during welding

_____j. American Welding Society

1. Shielded metal arc welding
2. Weld metal
3. Base metal
4. Puddle
5. Arc length
6. Tack weld
7. Spatter
8. Flux
9. Pass
10. AWS

2. Name two types of arc welding machines.

a. ____________________

b. ____________________

3. Distinguish between straight and reverse polarity by placing an "X" before the statement that signifies reverse polarity.

_____a. Current flows from electrode to base metal

_____b. Current flows from base metal to electrode

4. Name the two types of operating adjustments found on arc welding machines.

a. ____________________

b. ____________________

5. Name two common types of electrodes.

a. ____________________

b. ____________________

6. Name two common sizes of electrodes.

a. ____________________

b. ____________________

7. Select the statement which determines electrode size by placing an "X" in the appropriate blank.

_____a. Length of electrode

_____b. Diameter of bare end of electrode

_____c. Type of flux on electrode

8. Select the purposes of flux coating on electrodes by placing an "X" in the appropriate blanks.

_____a. Stabilizes arc

_____b. Makes arc starting difficult

_____c. Shields molten puddle from air

_____d. Provides deoxidizers and scavengers to prevent porosity of weld zone _____e. Keeps moisture out of filler metal

_____f. Forms slag and slows cooling

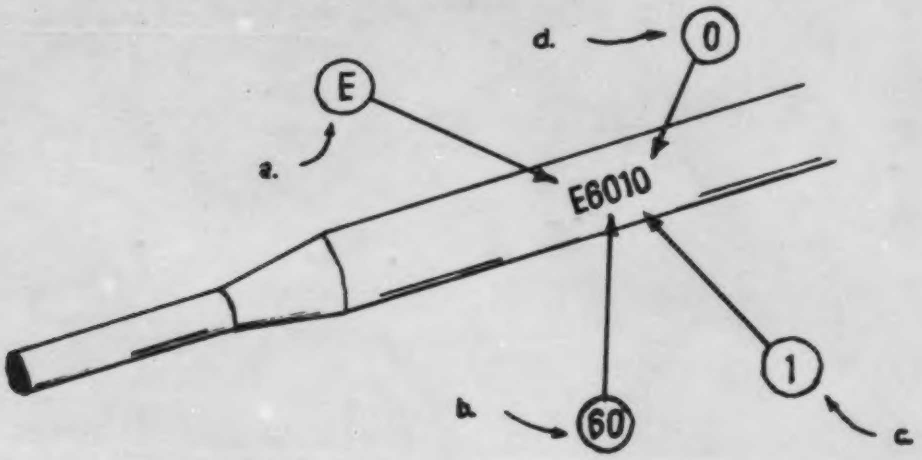
9. Identify the numbers in the AWS electrode classification.

a.____

b.____

c.____

d.____



10. Name four factors to be considered when selecting an electrode for a specific job application.

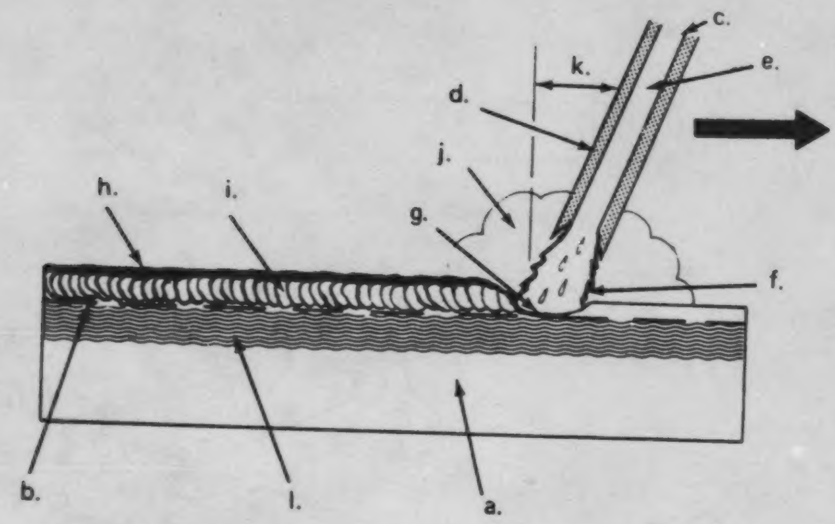
a.____

b.____

c.____

d.____

11. Identify the parts of the welding process.



a.______________________ b.______________________

c.______________________ d.______________________

e.______________________ f.______________________

g.______________________ h.______________________

i.______________________ j.______________________

k.______________________ l.______________________

12. Name the two methods of striking an arc.

a.____

b.____

13. State the correct range of lens shade number for electric welding.

____

14. List two reasons for removing slag from a weld.

a.____

b.____

15. List two reasons for fusing one bead in with another.

    a.________________________________

    b.________________________________

16. List six reasons for improperly formed beads.

    a.________________________________

    b.________________________________

    c.________________________________

    d.________________________________

    e.________________________________

    f.________________________________

17. Demonstrate the ability to:

    a. Start, stop, and restart a bead.

    b. Make a pad in the flat position.

    c. Make a square groove butt weld.

    d. Make a multiple pass T-joint fillet weld.

    (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

ELECTRIC WELDING
UNIT III

ANSWERS TO TEST

1. a. 1
   b. 5
   c. 3
   d. 8
   e. 4
   f. 6
   g. 7
   h. 9
   i. 2
   j. 10

2. a. AC (alternating current) transformer welder
   b. AC-DC transformer rectifier

3. b

4. a. Current (amperage) settings
   b. Polarity

5. a. Mild steel
   b. Stainless steel

6. Any two of the following:
   a. 3/32"
   b. 1/8"

7. b

8. a, c, d, f

9. a. Electrode
   b. Tensile strength deposited in thousand pounds per square inch
   c. Welding position
      1) All positions
      2) Flat and horizontal

- d. Special characteristics and usability of the rod
  - 1) Current
  - 2) Penetration
  - 3) Type of flux coating

10. Any four of the following:
    - a. Base metal strength properties
    - b. Base metal composition
    - c. Welding position
    - d. Welding current
    - e. Joint design and fit-up
    - f. Thickness and shape of base metal

11. a. Base metal
    - b. Penetration
    - c. Electrode
    - d. Coating
    - e. Wire core
    - f. Arc
    - g. Crater
    - h. Slag
    - i. Weld
    - j. Gaseous shield
    - k. Ten degrees--fifteen degrees
    - l. Heat lines

12. a. Tapping
    - b. Scratching

13. 9-14

14. Any two of the following:
    - a. Permits better fusion of beads
    - b. Prevents gas pockets and slag inclusions from forming in bead
    - c. Improves appearance of bead
15. Any two of the following:
    - a. Increases strength of weld
    - b. Improves appearance of bead
    - c. Improves penetration
16. Any six of the following:
    - a. Current adjusted too high
    - b. Current adjusted too low
    - c. Voltage adjusted too high
    - d. Voltage adjusted too low
    - e. Speed too slow
    - f. Speed too high
    - g. Improper electrode or size
    - h. Improper arc length
    - i. Improper angle of electrode
    - j. Improper preparation of base metal
17. Performance skills evaluated to the satisfaction of the instructor.

GAS TUNGSTEN ARC WELDING
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms of the GTAW process with their definitions and identify the applications and advantages of the process. The student should also be able to identify major parts of the equipment and the function of each. He/she should be familiar with the appropriate filler metals and demonstrate the ability to set up the equipment and produce welds on the popular metals in the flat, horizontal, and vertical positions on common joints. This knowledge will be evidenced by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with the GTAW process with the correct definition.
2. Match GTAW components to their proper application.
3. Identify parts of the GTAW process.
4. Name three applications of the GTAW process.
5. Select five advantages of the GTAW welding process.
6. Identify the major controls of the GTAW power supply.
7. Name the two types of welding current used most in the GTAW process.
8. Identify the six major parts of a GTAW torch.
9. Name the color and application when given the type of tungsten electrode.
10. Match the correct filler metal to the base metal being welded.
11. List three major metallurgical factors to be considered when welding aluminum.

12. Match given illustrations of poor welds with the cause of each.

13. Name five characteristics of a good weld.

14. List the four characteristics of argon shielding gas used in the GTAW process.

15. Demonstrate the ability to:

    a. Set up the GTAW power supply, select and adjust the correct current for aluminum, and shut down the equipment.

    b. Clean aluminum both mechanically and chemically.

    c. Run stringer beads on one-sixteenth inch aluminum in the flat position with filler rod.

    d. Construct a square groove butt weld on one-eighth inch aluminum in the flat position with filler rod.

    e. Construct a lap joint fillet weld on one-eighth inch aluminum in the horizontal position with filler rod.

    f. Construct an outside corner fillet weld joint on one-eighth inch aluminum in the flat position without filler rod.

    g. Construct a T-joint fillet weld on one-eighth inch aluminum in the horizontal position with filler rod.

    h. Construct a T-joint fillet weld on one-eighth inch aluminum in the vertical up position with filler rod.

GAS TUNGSTEN ARC WELDING
UNIT IV

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide students with objective sheet.

  B. Provide students with information, assignment, and job sheets.

  C. Discuss unit and specific objectives.

  D. Discuss information and assignment sheets.

  E. Demonstrate and discuss procedures outlined in job sheets.

  F. Give test.

II. Students:

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete assignment sheet.

  D. Demonstrate the ability to accomplish the procedures outlined in the job sheets.

  E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objectives

  B. Information sheet

  C. Transparencies

    1. TM 1--GTAW Equipment

    2. TM 2--GTAW Process

    3. TM 3--GTAW Power Supply

    4. TM 4--GTAW Torch

5. TM 5a and 5b--GTAW Electrodes
6. TM 6--Causes of Poor Welds
7. TM 7--Example of a Good Weld

D. Assignment sheets

1. Assignment Sheet #1--Aluminum Filler Metals

E. Answers to assignment sheet

F. Job sheets

1. Job Sheet #1--Set Up and Shut Down Power Supply for Welding Aluminum
2. Job Sheet #2--Metal Preparation of Aluminum Before Welding
3. Job Sheet #3--Make Stringer Beads on One-Sixteenth Inch Aluminum with Filler Rod in the Flat Position
4. Job Sheet #4--Construct a Square Groove Butt Weld on One-Eighth Inch Aluminum in the Flat Position
5. Job Sheet #5--Make a Lap Joint Fillet Weld on One-Eighth Inch Aluminum With Filler Rod in the Horizontal Position
6. Job Sheet #6--Construct a Corner Joint Fillet Weld on One-Eighth Inch Aluminum Without Filler Rod in the Flat Position
7. Job Sheet #7--Weld a T-Joint Fillet Weld on One-Eighth Inch Aluminum With Filler Rod in the Horizontal Position
8. Job Sheet #8--Construct a T-Joint Fillet Weld on One-Eighth Inch Aluminum With Filler Rod in the Vertical Up Position

G. Test

H. Answers to test

II. References:

A. Griffin, Ivan H. and Edward M. Roden. Basic TIG and MIG Welding. New York; Delmar Publishing Company.

B. Sullivan, R.P. Fundamentals and Theory of Tungsten Inert Gas Arc Welding. Newark, New Jersey: Linde Division Union Carbide.

C. Birdsall, G.W. Fusion Welding Aluminum. Richmond, Virginia: Reynolds Metals Company.

D. Hobart Welding Guide and Lessons. Troy, Ohio: Hobart School of Welding Technology.

E. Hobart Welding School Workbook. Troy, Ohio: Hobart School of Welding Technology.

F. Jefferson, T.B. and Gorham Woods. Metals and How to Weld Them. Cleveland, Ohio: James F. Lincoln Foundation.

G. The Welding Encyclopedia. Morton Grove, Illinois: The Welding Engineer Publishing Company Monticello Books.

H. Welding Alcoa Aluminum. Pittsburg, Pennsylvania: Aluminum Company of America.

I. Welding Handbook. Sixth Edition. Miami, Florida: American Welding Society.

J. Welding Kaiser Aluminum. Oakland, California: Kaiser Aluminum and Chemical Sales Inc.

GAS TUNGSTEN ARC WELDING
UNIT IV

INFORMATION SHEET

I. Terms and definitions

A. Gas Tungsten Arc Welding (GTAW) (Transparencies 1 and 2)--An arc welding process wherein coalescence (fusion) is produced by heating with an arc between a non-consumable tungsten electrode and the base metal utilizing an inert gas, argon, or helium that shields the weld zone from contamination by oxygen and nitrogen in the air

(NOTE: TIG is a common term used to describe this process.)

B. Inert shielding gas--A gas, which will not combine with other gases used to surround the weld zone and prevent contamination of the weld by oxygen and nitrogen in the air

C. Tungsten electrode--A practically non-consumable welding electrode used to create an intense arc between the tip of the electrode and the work

D. High frequency current--A high voltage low power source introduced into the A. C. weld current to start the arc and aid in oxide removal when welding aluminum

E. Flowmeter--A calibrated metering device used to regulate the flow of gases to the torch and measured in cubic feet per hour (c.f.h.)

F. Collet--A chucking device used to hold the tungsten in the torch

G. Collet body or (chuck)--A holding device for the collet

H. Foot control--A device used by the welder to control welding current during the welding process

I. Gas cup--An attachment that fits on the end of the GTAW torch to direct the flow of shielding gas to the tungsten and weld zone

J. Thermal conductivity--The characteristic of a metal to conduct heat throughout its thickness, width, and length

- K. Metallurgy--The science and technology of metals
- L. Aluminum oxide--A thin film that forms on the surface of aluminum due to a reaction between the metal and oxygen in the air

II. GTAW equipment components (Transparency 1)

- A. A. C. or D. C. welder machine--Provides power and control of the welding process
- B. Drain--Outlet for water circulated during the welding operation
- C. Inert gas supply--Used to prevent contamination of the weld zone by oxygen and nitrogen in the air
- D. Flowmeter--Used to measure the flow of gases to the torch

  (NOTE: The flowmeter is calibrated in cubic feet per hour.)
- E. Cooling water supply valve--Used to control the flow rate of cooling water to the torch
- F. Torch--Provides the heat and shielding gas for welding
- G. Filler rod--Material used to form the bond between or on the base metals
- H. Work--Metal to be repaired or bonded together
- I. Foot pedal--Remote control of the welding process

III. Parts of the GTAW process (Transparency 2)

- A. Tungsten electrode--Provides the necessary arc for fusion of the filler material to the base metal
- B. Molten weld pool--Combination of filler material and base metal
- C. Inert gas shield--Protects the weld pool from oxygen and nitrogen in the air

D. Arc stream--Provides the heat necessary to melt the filler material and base metal

E. Base metal--Material to be welded

F. Filler rod--Used to reinforce the weld area of the base metal

G. Backup bar--Used as a heat sink to prevent burn through of the base metal and control warping

IV. Applications of GTAW

A. Makes top quality welds possible on most all metals and alloys used in industry

B. Welds possible in all positions through a wide range of metal thickness

C. Used particularly for aluminum and its alloys (even on very thin sections)

V. Advantages of GTAW

A. No flux used and no post cleaning required

B. Arc and weld puddle clearly visible to welder

C. No slag or spatter

D. Makes excellent root pass on carbon and stainless steel pipe

E. Minimum of distortion and stress with heat concentrated in a small area

F. Welder has very close control of welding current

VI. GTAW power supply controls (Transparency 3)

A. Weld control switch--SMAW or GTAW welding

B. Current range selector

C. Fine adjustment current control

D. Polarity switch--current type

1. AC

2. DCSP

3. DCRP

E. High frequency

1. Start only position

2. Continuous position

3. Off position

4. Intensity rheostat

F. Gas and water connections in and out with solenoid valves

G. Terminals

1. Ground

2. Electrode

H. Remote control

1. Receptacles--Foot control

2. Control switch

a. Remote

b. Manual

I. Shielding gas afterflow timer (post purge 0-60 seconds)

J. Soft start--Reduces current during starting

VII. GTAW current

A. Alternating current (AC) with high frequency for aluminum and magnesium

B. Direct current straight polarity (DCSP) for mild and stainless steel

VIII. Major parts of the GTAW torch (Transparency 4)

A. Cap--Holds and tightens tungsten electrode in collet

B. Electrode--Tungsten

C. Collet--Holds tungsten electrode

D. Collet holder (body)--Holds collet with threads for holding gas cup (nozzle)

E. Gas cup--Nozzle directs the flow of shielding gas around the tungsten to the weld zone preventing contamination of the electrode and the weld

F. Torch body--Provides assembly point for the collet and gas cup

IX. Tungsten electrodes (Transparencies 5a and 5b)

Type of Electrode	Color	Finish	Sizes	Application
Pure	Green	Ground or Chemically Etched	1/16, 3/32, 1/8, 5/32, 3/16, 1/4	Aluminum and Magnesium
Zirconiated	Brown	" "	" "	X-Ray Quality for Aluminum or Magnesium

(NOTE: Tungsten electrodes have a high melting point (6900°F) and are practically nonconsumable. The electrode should never touch the molten weld puddle. Electrodes contaminated by contact with weld puddle must be reground or they produce a sputtering arc and weld contamination.)

X. GTAW filler metals

A. Aluminum

GUIDE TO THE CHOICE OF FILLER METAL
FOR GTAW WELDING ALUMINUM

		H	G	F	E	D	C	B	A
	Base Metal	Casting Alloys		6061 6063	5454	5086 5356	5052 5652 (1)	3004 CLAD 3004	1100 3003 CLAD 3003
		43 356	214 F214						
A	1100, 3003 CLAD 3003	ER4043	ER4043 (5)	ER4043 (5)	ER4043 (5)	ER5356 (3)(5)	ER4043 (5)	ER4043 (5)	ER1100 (3)
B	3004, CLAD 3004	ER4043	ER4043 (5)	ER4043 (2)	ER5356 (3)(5)	ER5356 (5)	ER5356 (3)(5)	ER4043 (4)(5)	
C	5052 5652(1)	ER4043	ER4043 (2)	ER4043 (2)	ER5356 (2)(3)	ER5356 (5)	ER5652 (2)(3)		
D	5086 5356	ER5356 (3)(5)	ER5356 (5)	ER5356 (5)	ER5356 (5)	ER5356 (5)			
E	5454	ER5356 (3)(5)	ER5356 (2)	ER5356 (2)(3)	ER5554 (5)				
F	6061 6063	ER4043 (5)	ER5356 (2)(3)	ER5356 (2)(3)					
G	214 F214	ER4043 (5)	ER5356 (2)						
H	43 356	ER4043							

(1) Base metal alloys 5652 and 5254 are used for hydrogen peroxide service. ER5254 filler metal is used for welding both alloys for low temperature service (150 F and below.) ER5652 filler metal is used for welding 5652 for high temperature service (150 F and above).

(2) ER5154, ER5254, ER5183, ER5356, ER5554, and ER5556 may be used. In some cases, they provide: 1—improved color match after anodizing treatment. 2—highest weld ductility, and 3--higher weld strength. ER5554 is suitable for elevated temperature service.

(3) ER4043 may be used for some applications.

(4) Filler metal with the same analysis as the base metal is sometimes used.

(5) ER5356, ER5183, or ER5556 may be used.

Courtesy of Hobart Brothers Technical Center, Troy, Ohio.

(NOTE: The composition of the filler metal should be matched to that of the base metal. The size of the filler metal rod is determined by the thickness of base metal and welding current.)

XI. Welding metallurgy

A. Aluminum

1. Melting point--Aluminum melts at 1220°F but requires higher welding currents than other metals due to its high thermal conductivity

(NOTE: Aluminum dissipates heat away from the weld zone five times faster than steel. This requires a high heat input (amperage) to obtain a puddle. It also means the weld puddle solidifies (sets up) faster and makes out-of-position welding easier.)

2. Aluminum oxide--Forms on the surface of aluminum when exposed to oxygen in the air; this oxide requires a temperature of 3700°F to melt or break down

(NOTE: At welding temperatures, oxygen in the air combines with the exposed aluminum to reform the oxide. With inert gas to shield the weld zone and the reverse polarity cycle of AC current to remove the oxide, the problem is eliminated.)

3. Heat colors--Aluminum shows no heat colors as it approaches the melting point

(NOTE: With the GTAW process, the metal takes on a shiny or wet appearance when melting occurs.)

4. Proper mechanical support--Since some aluminum alloys melt at 900°F, care must be taken to support all areas subjected to the extreme heat of welding to prevent collapse, warping, and distortion

XII. Causes of poor welds (Transparency 6)

A. Welding current too low

B. Welding current too high

C. Arc too long

D. Welding speed too fast

E. Welding speed too slow

F. Contaminated tungsten

XIII. Characteristics of a good weld (Transparency 7)

A. Smooth edge

B. Correct bead size

C. Even penetration

D. Even ripple

E. Clean bright weld

XIV. Characteristics of argon

A. Argon--Most popular gas for GTAW

1. Easily obtainable at low cost

2. Better shielding at lower flow rates (c.f.h.) than helium

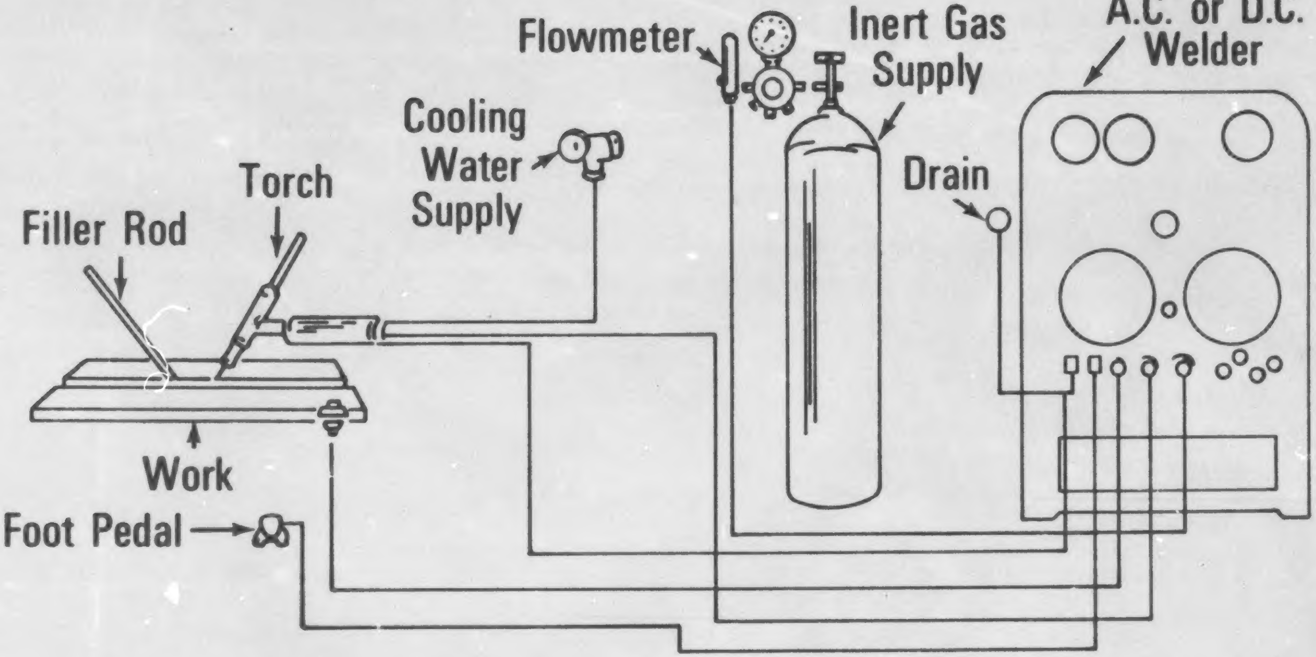
(NOTE: Argon is ten times heavier than helium)

3. Easier arc starting than helium

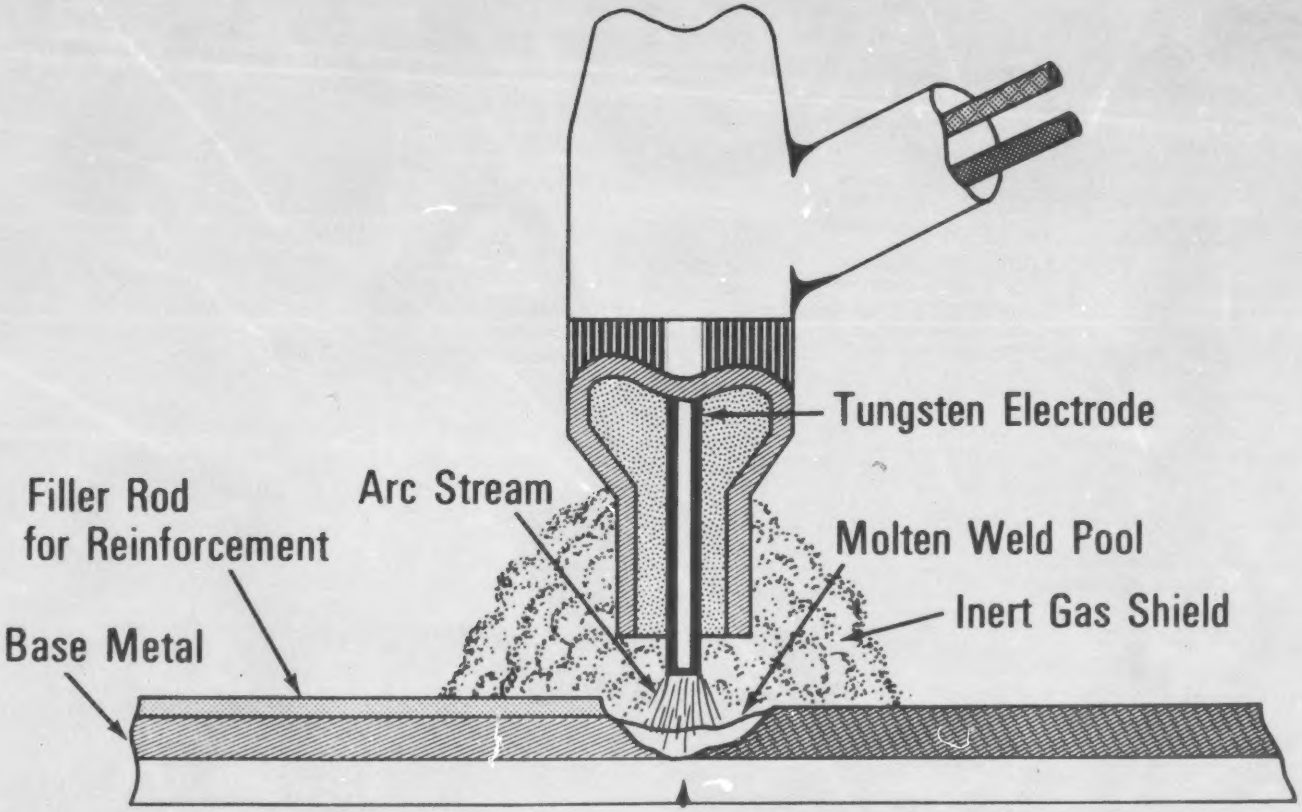
4. Better cleaning action when welding aluminum with AC current

(NOTE: Argon-Helium mixes are used when excellent cleaning and high heat input is needed for thick plates.)

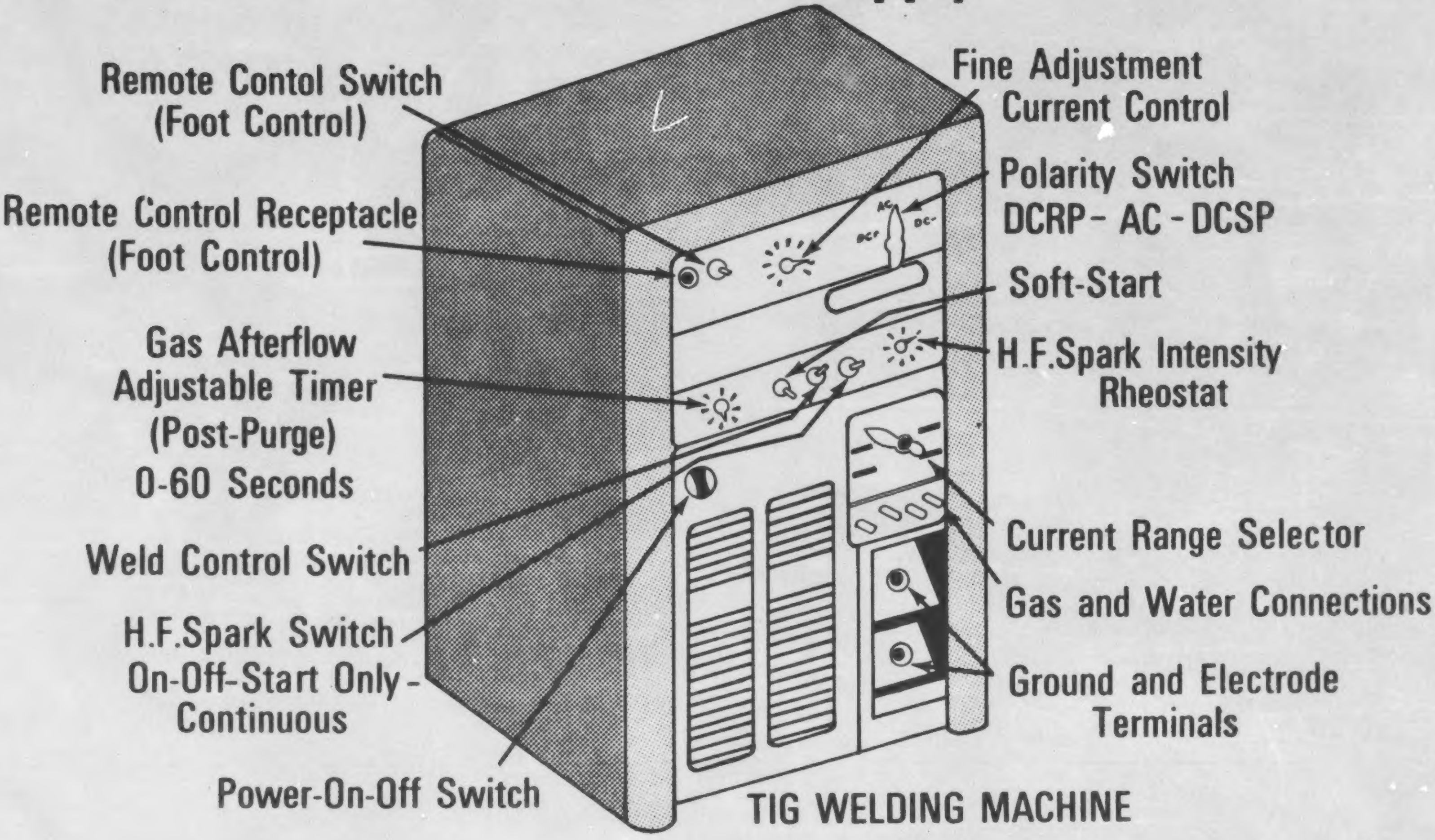
GTAW Equipment



GTAW Process

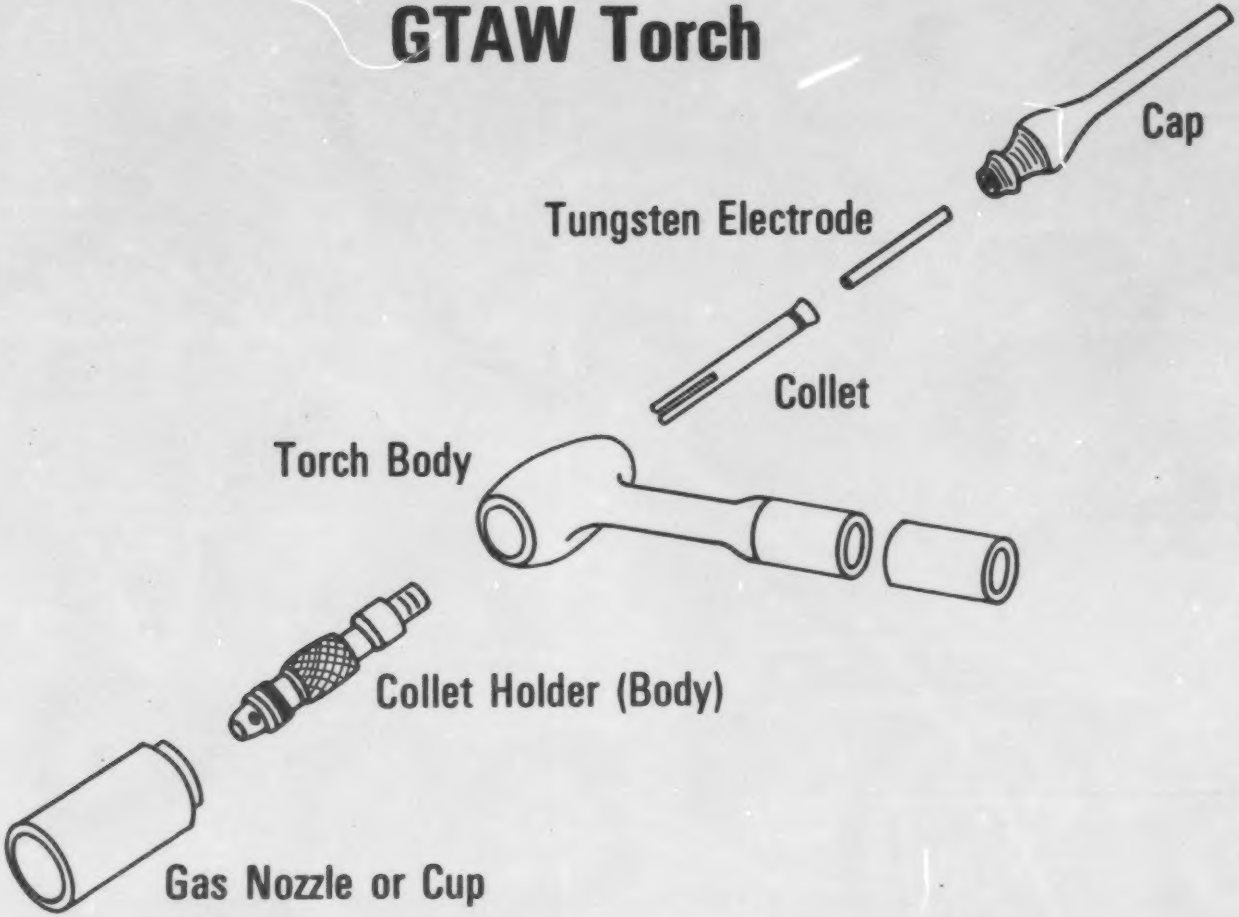


GTAW Power Supply


Remote Contol Switch (Foot Control)
Remote Control Receptacle (Foot Control)
Gas Afterflow Adjustable Timer (Post-Purge) 0-60 Seconds
Weld Control Switch
H.F.Spark Switch On-Off-Start Only - Continuous
Power-On-Off Switch
Fine Adjustment Current Control
Polarity Switch DCRP - AC - DCSP
AC
DCP
DC-
Soft-Start
H.F.Spark Intensity Rheostat
Current Range Selector
Gas and Water Connections
Ground and Electrode Terminals

TIG WELDING MACHINE

GTAW Torch

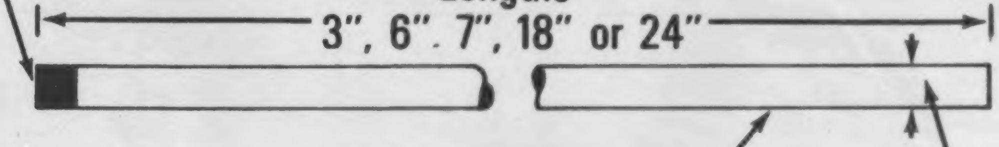

Cap
Tungsten Electrode
Collet
Torch Body
Collet Holder (Body)
Gas Nozzle or Cup

GTAW Electrodes

TUNGSTEN ELECTRODES

Electrodes Available

Color Code	Metal or Alloy
Green	Pure Tungsten
Yellow	1% Thorium
Red	2% Thorium
Brown	Zirconium



Lengths

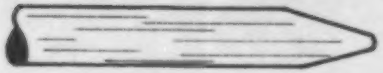
3", 6". 7", 18" or 24"

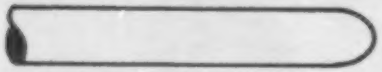
Finish
Chemically Etched
Ground

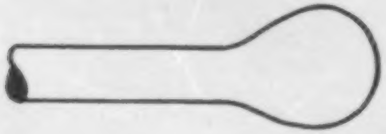
Standard Diameters
Finishes and Lengths
1/16", 3/32", 1/8", 5/32", 3/16", and 1/4"

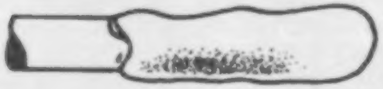
GTAW Electrodes

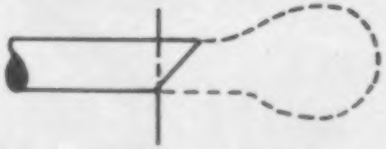
PREPARE ELECTRODE

A  Good Condition- Pull point-with grind marks running lengthwise-(steel & stainless)

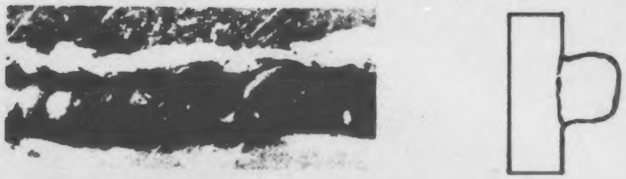
B  Good Condition- Shiny, round end-(aluminum & magnesium)

C  Too Much Current- Match head shape

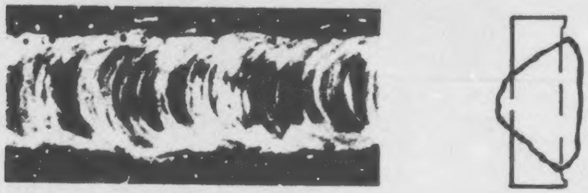
D  End Contaminated With Base Metal- Electrode touched puddle or filler rod (similar to C, but uneven and longer)

E  Break off ends at dotted lines, if condition C or D exists. If electrode breaks at angle, grind off flat.

Causes of Poor Welds

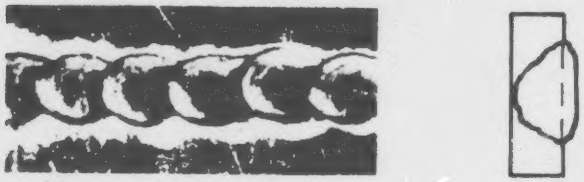


Welding Current Too Low

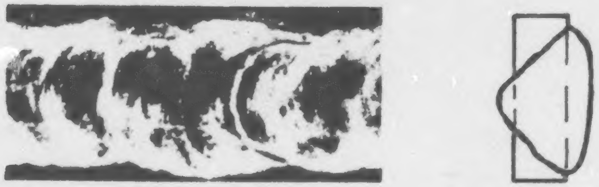


Welding Current Too High

Arc Too Long (voltage too high)



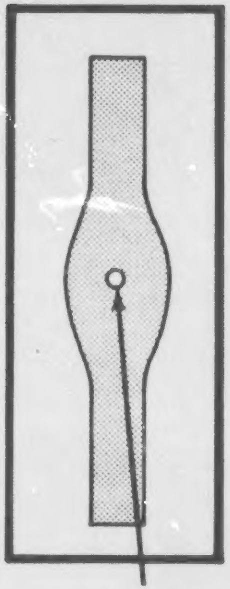
Welding Speed Too Fast



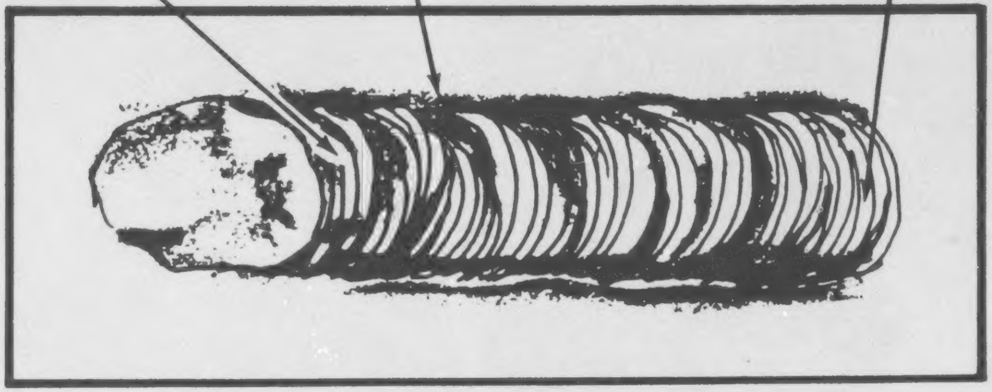
Welding Speed Too Slow

S-147-E

Example of a Good Weld



Even Penetration



Even Ripple

Smooth Edge

Correct Bead Size

Clean, Bright Weld

GAS TUNGSTEN ARC WELDING
UNIT IV

ASSIGNMENT SHEET #1--ALUMINUM FILLER METALS

Using the aluminum chart, in the information sheet, answer the following questions:

1. What filler metal should be used to weld base metal 3004?

   ____

2. What filler metal should be used to weld base metals 6061 and 6063?

   ____

3. What type of filler metal would be required for 5454?

   ____

4. What filler metal would be used for 5052 base metal?

   ____

5. For base metal 3003, you would use ________________ filler metal.

GAS TUNGSTEN ARC WELDING
UNIT IV

ANSWERS TO ASSIGNMENT SHEET

1. ER4043
2. ER5356
3. ER5454
4. ER5652
5. ER1100

GAS TUNGSTEN ARC WELDING
UNIT IV

JOB SHEET #1--SET UP AND SHUT DOWN POWER SUPPLY FOR WELDING ALUMINUM

I. Equipment and materials

- A. GTAW power supply and required equipment
- B. Argon--Shielding gas
- C. Pure or zirconiated tungsten
- D. Collet and collet chuck (body)
- E. Nozzle
- F. Aluminum filler rod
- G. Aluminum--Welding grade

II. Procedure

- A. Set up power supply
  1. Set current range selector--Low, medium, or high--Depends on metal thickness
     - a. Low--2-60 amps
     - b. Medium--10-250 amps
     - c. High--20-300 amps
  2. Fine control to maximum within each range
  3. Set polarity switch to AC
  4. Set weld control switch to GTAW
  5. Set high frequency control to
     - a. Continuous
     - b. Intensity--Spark control to medium
  6. Switch power to "on" position
  7. Mount flowmeter to argon cylinder

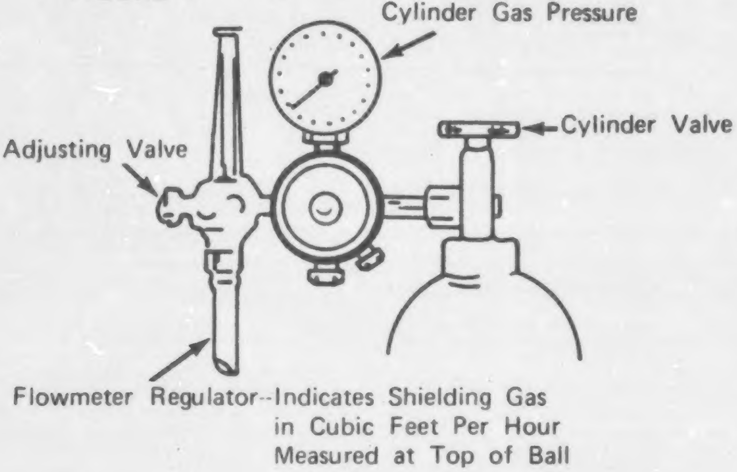
a. Crack cylinder slowly

b. Check for leaks using ivory soap

c. Mount in vertical position

(NOTE: This is accurate only if gas in cylinder exceeds 50 p.s.i.) (Figure 1)

FIGURE 1


Cylinder Gas Pressure
Cylinder Valve
Adjusting Valve
Flowmeter Regulator--Indicates Shielding Gas in Cubic Feet Per Hour Measured at Top of Ball

8. Adjust shielding gas flow rate (cubic foot hour)

   (NOTE: Measured at the top of ball.)

9. Adjust post purge (gas afterflow) timer to 15 seconds (1-60 seconds)

10. Set soft start to "on" position

11. Set foot control switch to remote

B. Torch adjustments

1. Select pure or zirconiated tungsten of correct size

2. Prepared tungsten should have a shiny balled end (Figure 2)

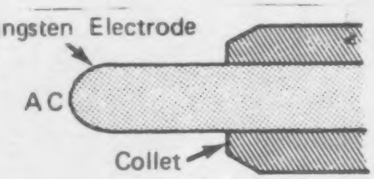
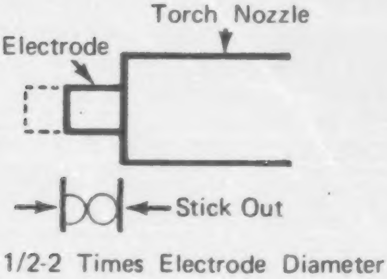


FIGURE 2

3. Select correct size collet, collet chuck, and cup or nozzle

4. Adjust electrode stick out (Figure 3)

FIGURE 3



(NOTE: Stick out distance can be increased when welding T-joints, groove welds, or other hard to reach joints. Gas flow rates should be increased accordingly.)

C. Connect ground clamp to base metal

D. Select correct filler rod size from chart below

GAS TUNGSTEN ARC (TIG) WELDING OF ALUMINUM

Material Thickness		Type of Weld (2)	Tungsten Electrode Dia. (3)	Filler Rod Dia. (4)	Nozzle Size I.D.	Shielding Gas C.F.H. (5)	Welding Current (Amps) AC-HF	Number of Passes	Travel Speed (I.P.M.)
3/64,	.046	Sq. groove	1/16	1/16	1/4	19	40-60	1	16
1/16,	.063	Sq. groove	3/32	3/32	5/16	19	70-90	1	11
1/16,	.063	Fillet	3/32	3/32	5/16	15	70-90	1	9
3/32,	.094	Sq. groove	3/32	3/32	5/16	19	90-110	1	11
3/32,	.094	Fillet	3/32	3/32	5/16	16	95-115	1	9
1/8,	.125	Sq. groove	1/8	1/8	3/8	20	115-135	1	11
1/8,	.125	Fillet	1/8	1/8	3/8	19	120-140	1	10
3/16	.187	Fillet	5/32	5/32	7/16	25	180-200	1	10
3/16	.187	V-groove	5/32	5/32	7/16	25	160-180	2	11
1/4	.250	Fillet	3/16	3/16	1/2	30	230-250	1	10
1/4	.250	V-groove	5/32	5/32	7/16	30	200-220	2	9
3/8	.375	Fillet	3/16	3/16	1/2	35	250-310	2-3	

1. Increase amperage when backup is used.

2. Data is for all welding positions.

3. For tungsten electrodes - 1st choice - pure tungsten green strip; 2nd choice - zirconated brown strip.

4. Normally Argon is used for shielding, however, mixtures of 10% or more helium with Argon are sometimes used for increased penetration in aluminum 1/4 inch thick and over. The gas flow should be increased when helium is added. A mixture of 75% He + 25% Argon is popular. When 100% helium is used, gas flow rates are about twice those used for Argon.

Courtesy of Hobart Brothers Technical Center, Troy, Ohio.

E. Shut down power supply

1. Place torch where it will not arc or fall in floor

   (NOTE: GTAW torch is delicate and should be handled with care.)

2. Close gas cylinder valve

3. Depress foot control to bleed gas line

4. Close gas flow adjusting valve

   (NOTE: Ball will rest at bottom of gauge.)

5. Shut off power switch

E. Shut down power supply

1. Place torch where it will not arc or fall in floor

   (NOTE: GTAW torch is delicate and should be handled with care.)

2. Close gas cylinder valve

3. Depress foot control to bleed gas line

4. Close gas flow adjusting valve

   (NOTE: Ball will rest at bottom of gauge.)

5. Shut off power switch

GAS TUNGSTEN ARC WELDING
UNIT IV

JOB SHEET #2--METAL PREPARATION OF ALUMINUM BEFORE WELDING

I. Equipment and materials

  A. Metal--Aluminum

  B. Stainless steel brush

  C. Milling or grinding machines available

  D. Chemical solutions

  E. Files for aluminum

II. Procedures

  A. Cleaning aluminum

    1. Scrub all joint surfaces to be welded with a clean stainless steel brush to remove dirt, paint, metal particles, and the oxide coating

    2. File the joint edges to remove the oxide coating

    3. Apply a solution of AB76 cleaner, diluted to 1 part AB76 and 12 parts of water

    4. Allow to set for ten minutes, then rinse well with water

    5. Wipe cleaned areas well with a clean, dry cloth

GAS TUNGSTEN ARC WELDING
UNIT IV

JOB SHEET #3--MAKE STRINGER BEADS ON ONE-SIXTEENTH INCH ALUMINUM WITH FILLER ROD IN THE FLAT POSITION

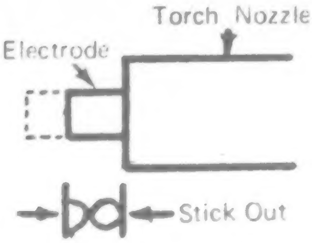
I. Equipment and materials

- A. GTAW power supply and required equipment
- B. Personal protective equipment
- C. Stainless steel wire brush (clean)
- D. Filler rod 3/32"
- E. Pure tungsten electrode 3/32", collet, and collet body
- F. Argon shielding gas 15-20 c.f.h.
- G. Two pieces, 1/16", 2" x 6" aluminum

II. Procedure

- A. Clean aluminum with stainless wire brush to remove oxide coating
- B. Check torch for the following
    - 1. Nozzle cup size 5/16" inside diameter
        - a. Unburnt
        - b. Even end with no cracks or chips
    - 2. Correct collet and collet body--3/32"
    - 3. Correct tungsten with the following
        - a. Round shiny end
        - b. Correct stick out (Figure 1)

FIGURE 1



1 1/2-2 Times Electrode Diameter

        c. Finger tighten cap to secure tungsten

C. Attach ground clamp

D. Set welding machine and turn on power

    1. AC current

    2. Current adjustment

        a. Coarse adjustment--middle range 10-250

        b. Fine adjustment--maximum

E. Set high frequency

    1. Continuous operation

    2. Rheostat to medium

F. Set shielding gas 15-20 c.f.h.

G. Set post purge to 15 seconds

H. Position metal flat on table

I. Position torch at 160°-75° angle to metal with no side angle (Figure 2)

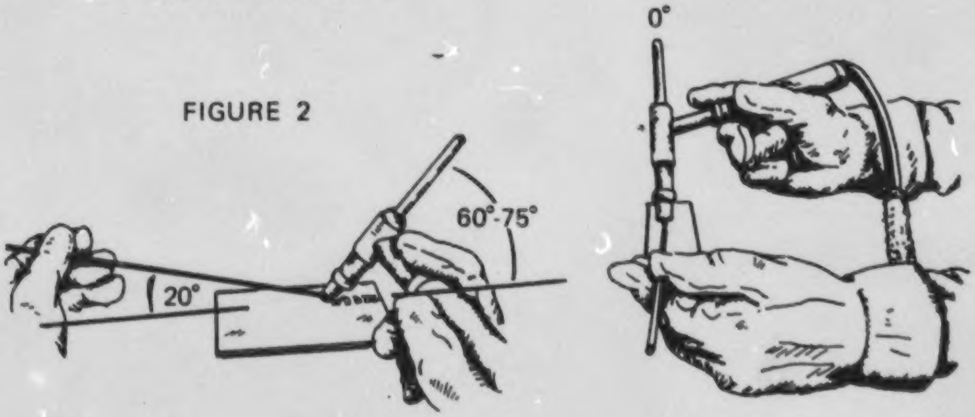


FIGURE 2

Weldor's View

End View

J. Hold electrode 1/16" from metal (See Figure 2.)

K. Hold filler rod at 20° angle to metal with no side angle (See Figure 2.)

L. Depress foot control at least half-way and establish arc and immediate puddle

(NOTE: Do not contact metal or filler rod with tungsten.)

M. Add filler rod in leading edge of puddle being careful to keep rod under shielding gas at all times

(NOTE: Consistent travel speed and addition of filler rod is the key to producing uniform beads of correct height and width.)

N. After each pass, switch or cool metal being careful to remove all moisture before welding

O. Have instructor inspect workpiece

GAS TUNGSTEN ARC WELDING
UNIT IV

JOB SHEET #4--CONSTRUCT A SQUARE GROOVE BUTT WELD ON ONE-EIGHTH INCH ALUMINUM IN THE FLAT POSITION

I. Equipment and materials

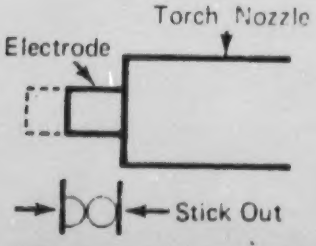
- A. GTAW power supply and required equipment
- B. Personal protective equipment
- C. Stainless steel wire brush (clean)
- D. Filler rod 1/8"
- E. Pure tungsten electrode 1/8" green strip

  (NOTE: One-eighth inch electrode requires a 1/8" collet and collet body.)
- F. Argon shielding gas 20 c.f.h.
- G. Material 2 - 1/8" x 2" x 6" aluminum

II. Procedure

- A. Clean aluminum with stainless wire brush to remove oxide coating
- B. Check torch for the following
  - 1. Nozzle (cup) size 3/8" inside diameter
    - a. Unburnt
    - b. Even end with no cracks or chips
  - 2. Correct collet and collet body--1/8"
  - 3. Correct tungsten with the following
    - a. Round shiny end
    - b. Correct stick out (Figure 1)

FIGURE 1



1 1/2-2 Times Electrode Diameter

c. Finger tighten cap to secure tungsten

C. Attach ground clamp

D. Set welding machine and turn on power

1. AC current

2. Current adjustment

a. Coarse adjustment--middle range 10-250

b. Fine adjustment--maximum

E. Set high frequency

1. Continuous operation

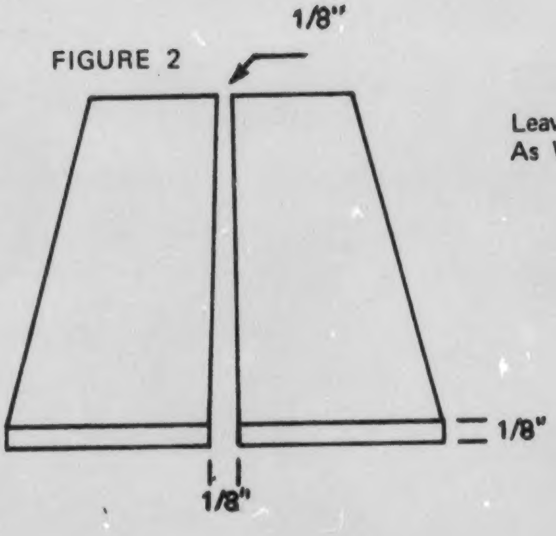
2. Rheostat to medium

F. Set shielding gas 15-20 c.f.h.

G. Set post purge to 15 seconds

H. Position two pieces of aluminum to form a butt joint leaving a 3/32" - 1/8" root opening (Figure 2)

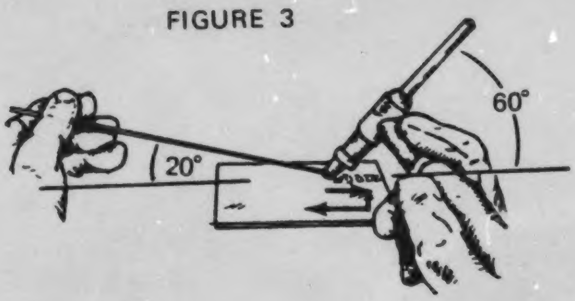
FIGURE 2



Leave Root Opening Between Plates As Wide As Material Is Thick

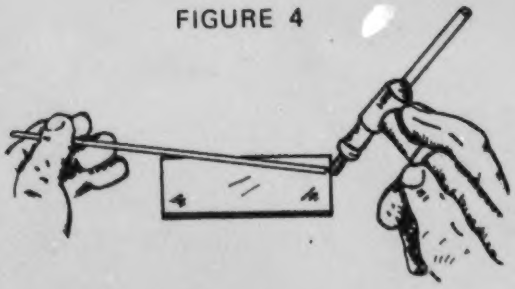
I. Position torch at a 60° angle to metal with no side angle and centered in joint (Figure 3)

FIGURE 3



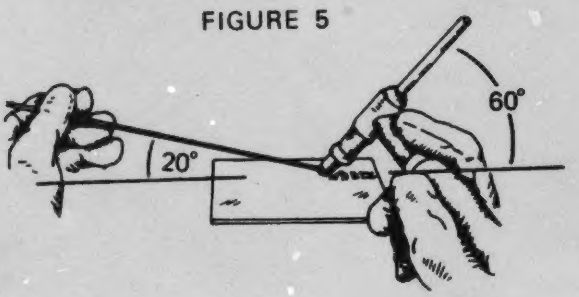
J. Hold electrode 1/16" from metal (Figure 4)

FIGURE 4



K. Position filler rod at a 20° to metal and centered in root opening of joint (Figure 5)

FIGURE 5



L. Depress foot control, establish arc, and tack each end

M. Move to end of joint, strike arc, and establish puddle by melting rod and both plate edges

(NOTE: As weld progresses, care should be taken to maintain consistent travel speed, torch and rod angle, and correct arc length.)

N. Amperage should be decreased slowly with additional filler rod added to prevent crater at the end of bead

O. Check root of weld for penetration and cool metal before welding other side

P. Check your work with instructor

GAS TUNGSTEN ARC WELDING
UNIT IV

JOB SHEET #5--MAKE A LAP JOINT FILLET WELD ON ONE-EIGHTH INCH ALUMINUM WITH FILLER ROD IN THE HORIZONTAL POSITION

I. Equipment and materials

   A. GTAW power supply and required equipment

   B. Personal protective equipment

   C. Stainless steel wire brush (clean)

   D. Filler rod 1/8"

   E. Pure tungsten electrode 3/32" green strip (See chart 3.)

      (NOTE: Three-thirty-second inch electrode requires a 3/32" collet and collet body.)

   F. Argon shielding gas 15-20 c.f.h.

   G. Two pieces, 1/8" x 2" x 6" aluminum

II. Procedure

   A. Clean aluminum with stainless wire brush to remove oxide coating

   B. Check torch for the following

      1. Nozzle (cup) size 3/8" inside diameter

         a. Unburnt

         b. Even end with no cracks or chips

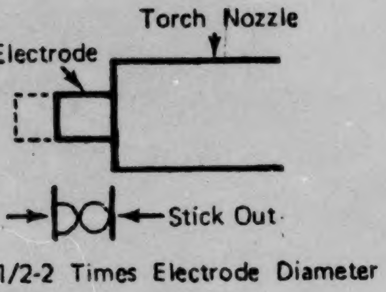
      2. Correct collet and collet body

      3. Correct tungsten with the following

         a. Round shiny end

         b. Correct stick out (Figure 1)

FIGURE 1



c. Finger tighten cap to secure tungsten

C. Attach ground clamp

D. Set welding machine and turn on power

1. AC current

2. Current adjustment

a. Coarse adjustment--middle range 10-250

b. Fine adjustment--maximum

E. Set high frequency

1. Continuous operation

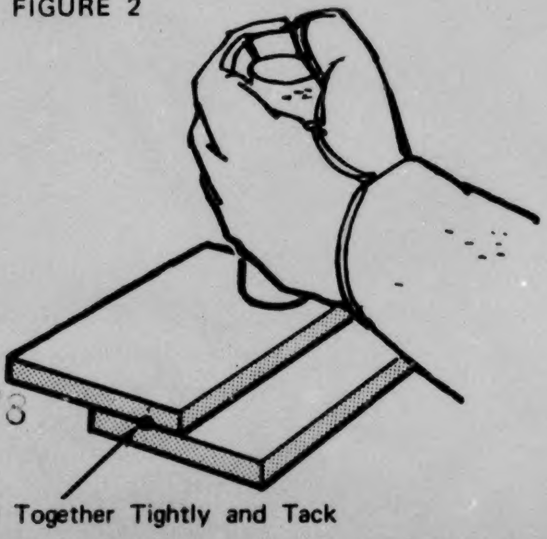
2. Rheostat to medium

F. Set shielding gas 15-20 c.f.h.

G. Set post purge to 15 seconds

H. Position two pieces of aluminum to form a lap joint as indicated (Figure 2)

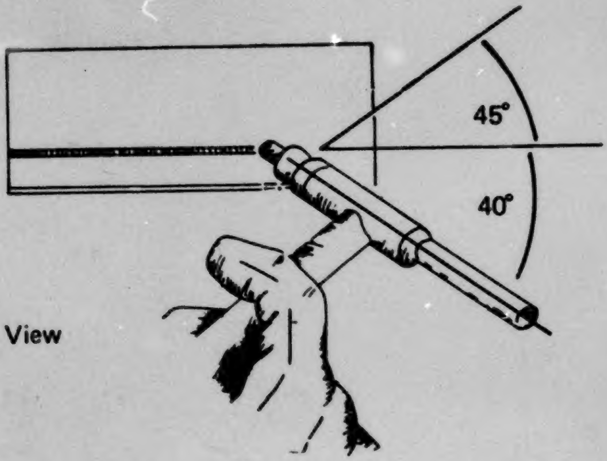
FIGURE 2


Hold Together Tightly and Tack

I. Tack both ends of joint with filler rod as indicated

J. Position torch at a 45° angle from table with a 40° side angle toward you (Figure 3)

FIGURE 3

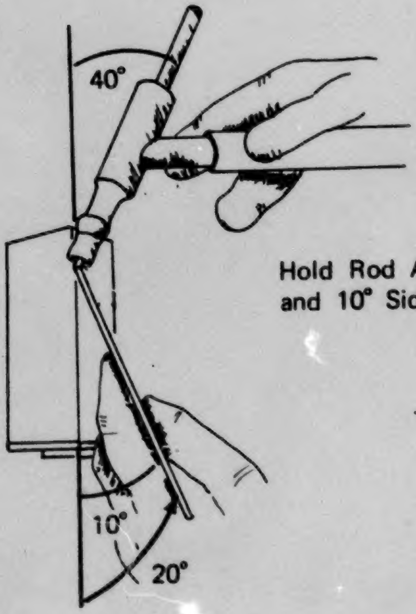


Weldor 's View

(NOTE: It may be helpful to extend electrode stick out 1/16"-1/8" to improve penetration to bottom of joint. Increase gas flow rate.)

K. Hold filler rod at a 20° angle from table with a 10° side angle toward you (Figure 4)

FIGURE 4



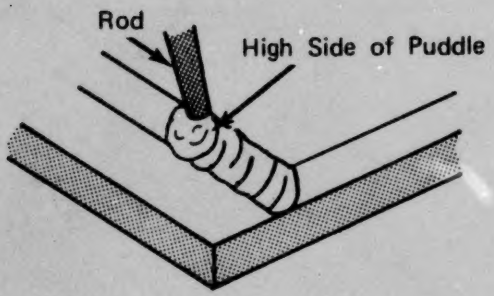
Hold Rod At 20° Angle from Table and 10° Side Angle (Toward You)

End View

L. Start arc, then move torch back to end of joint and form puddle

M. Dip filler rod in and out at high side of leading edge of puddle to prevent undercutting (Figure 5)

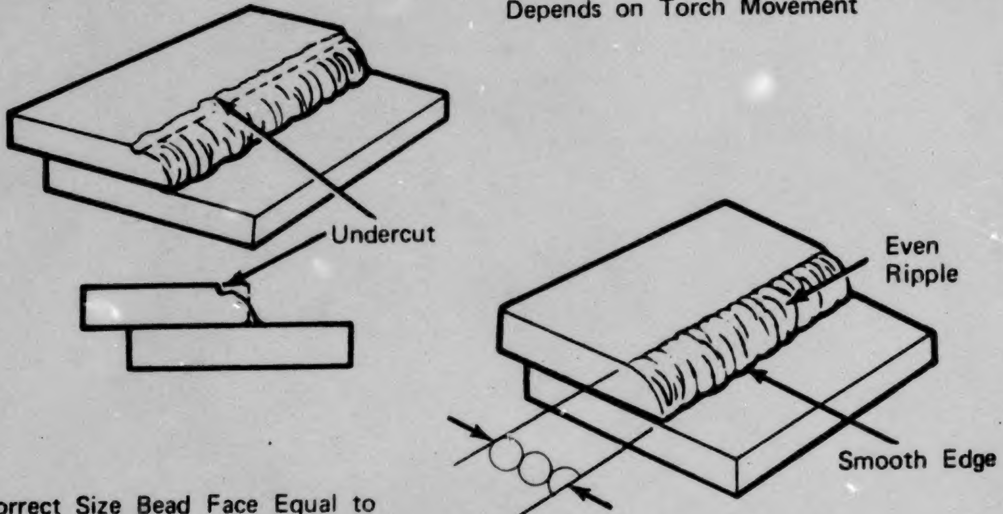
FIGURE 5



N. Inspect weld for undercutting and correct bead size with even ripples (Figure 6) and complete penetration (Figure 7)

FIGURE 6

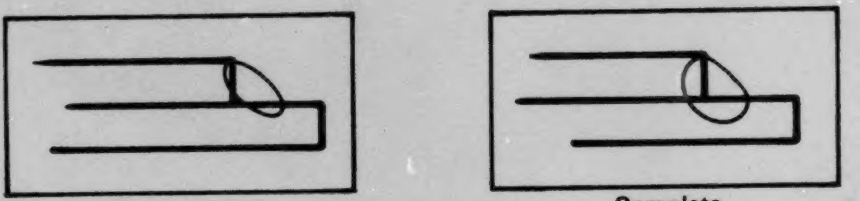
Undercutting Depends on Torch Movement



Correct Size Bead Face Equal to 2 1/2 to 3 Times Diameter of Electrode

FIGURE 7

Penetration



Incomplete

Complete

O. Cool and dry metal after each pass

P. Submit to instructor for inspection

GAS TUNGSTEN ARC WELDING
UNIT IV

JOB SHEET #6--CONSTRUCT A CORNER JOINT FILLET WELD ON ONE-EIGHTH INCH ALUMINUM WITHOUT FILLER ROD IN THE FLAT POSITION

I. Equipment and materials

   A. GTAW power supply and required equipment

   B. Personal protective equipment

   C. Stainless steel wire brush (clean)

   D. Pure tungsten electrode 3/32" green strip (See chart 3.)

   (NOTE: Three-thirty-second inch electrode requires a 3/32" collet and collet body.)

   E. Argon shielding gas 15-20 c.f.h.

   F. Two pieces, 1/8" x 2" x 6" aluminum

II. Procedure

   A. Clean aluminum with stainless wire brush to remove oxide coating

   B. Check torch for the following

      1. Nozzle (cup) size 3/8" inside diameter

         a. Unburnt

         b. Even end with no cracks or chips

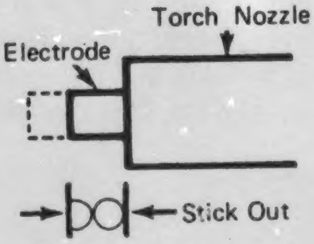
      2. Correct collet and collet body--1/8"

      3. Correct tungsten with the following

         a. Round shiny end

         b. Correct stick out (Figure 1)

FIGURE 1

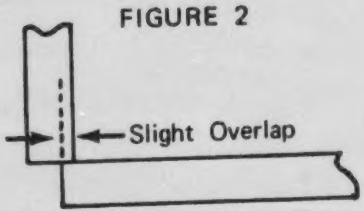


1 1/2-2 Times Electrode Diameter

        - c. Finger tighten cap to secure tungsten

- C. Attach ground clamp
- D. Set welding machine and turn on power
    - 1. AC current
    - 2. Current adjustment
        - a. Coarse adjustment--middle range 10-250
        - b. Fine adjustment--maximum
- E. Set high frequency
    - 1. Continuous operation
    - 2. Rheostat to medium
- F. Set shielding gas 15-20 c.f.h.
- G. Set post purge to 15 seconds
- H. Position two pieces of aluminum to form a right angle overlapping slightly (Figure 2)

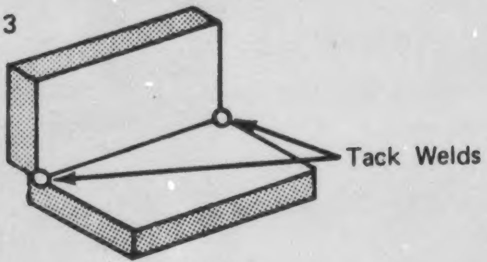
FIGURE 2



Hold Pieces Firmly in Place

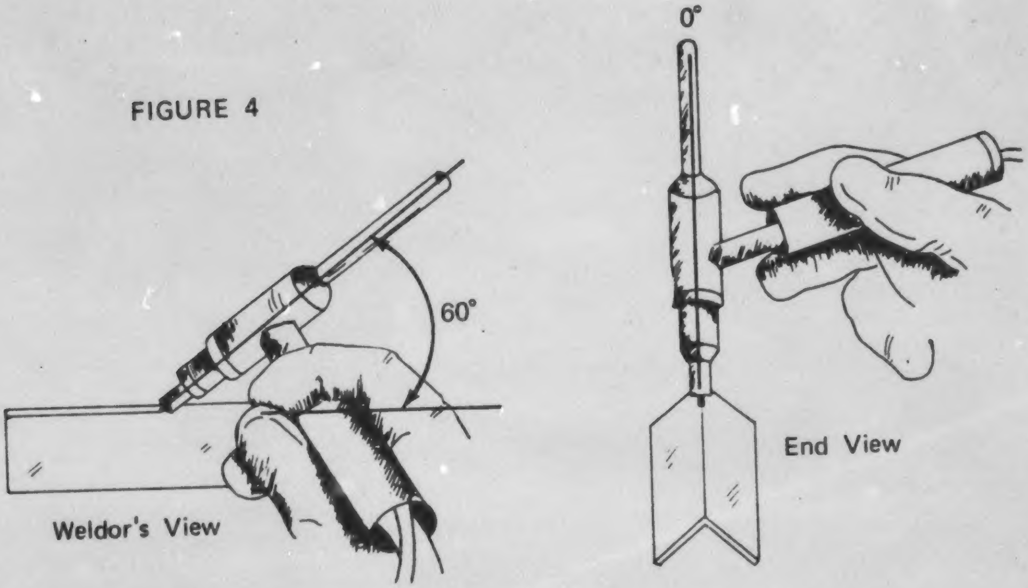
I. Tack each end of joint as indicated (Figure 3)

FIGURE 3



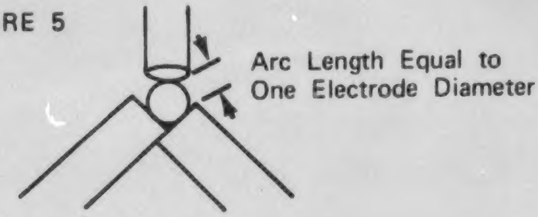
J. Position torch at 60° angle from table with nc side angle (Figure 4)

FIGURE 4



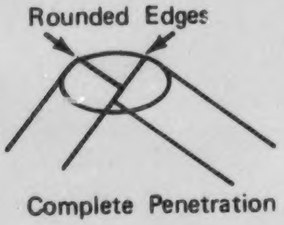
K. Start arc and maintain short arc length to flow metal into center of groove (Figure 5)

FIGURE 5



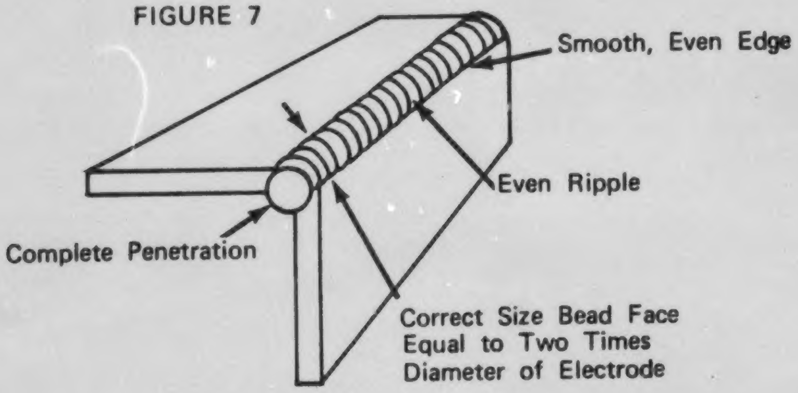
L. Weld at speed to round down joint edges and produce 100% penetration (Figure 6)

FIGURE 6



M. Inspect weld for smooth even edge and ripple, correct size bead, and complete penetration (Figure 7)

FIGURE 7



N. Submit to instructor for inspection

GAS TUNGSTEN ARC WELDING
UNIT IV

JOB SHEET #7--WELD A T-JOINT FILLET WELD ON ONE-EIGHTH INCH ALUMINUM WITH FILLER ROD IN THE HORIZONTAL POSITION

I. Equipment and materials

   A. GTAW power supply and required equipment

   B. Personal protective equipment

   C. Stainless steel wire brush (clean)

   D. Filler rod 1/8"

   E. Pure tungsten electrode 3/32" green strip (See chart 3.)

   (NOTE: Three-thirty-second inch electrode requires 3/32" collet and collet body.)

   F. Argon shielding gas 15-20 c.f.h.

   G. Two pieces, 1/8" x 2" x 6" aluminum

II. Procedure

   A. Clean aluminum with stainless wire brush to remove oxide coating

   B. Check torch for the following

      1. Nozzle (cup) size 3/8" inside diameter

         a. Unburnt

         b. Even end with no cracks or chips

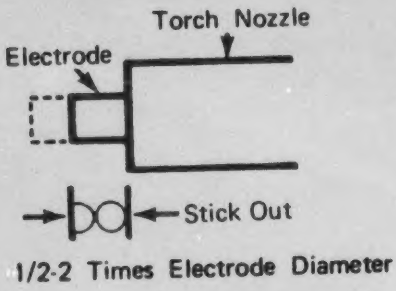
      2. Correct collet and collet body

      3. Correct tungsten with the following

         a. Round shiny end

         b. Correct stick out (Figure 1)

FIGURE 1



        c. Finger tighten cap to secure tungsten

(NOTE: It may be helpful to extend tungsten 1/16-1/8" to aid weldor's view stick out of puddle and increase penetration.)

C. Attach ground clamp

D. Set welding machine and turn on power

   1. AC current

   2. Current adjustment

      a. Coarse adjustment--middle range 10-250

      b. Fine adjustment--maximum

E. Set high frequency

   1. Continuous operation

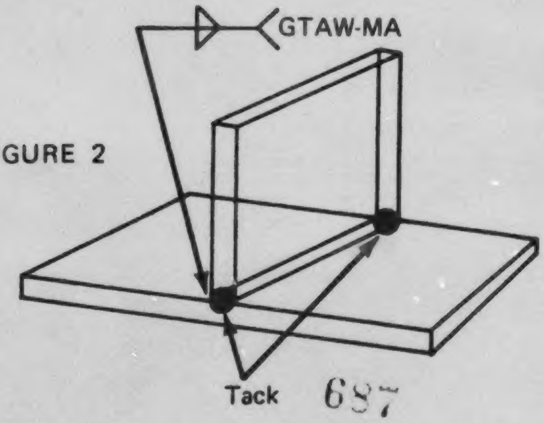
   2. Rheostat to medium

F. Set shielding gas 15-20 c.f.h.

G. Set post purge to 15 seconds

H. Position two pieces of aluminum to form a T-joint (Figure 2)

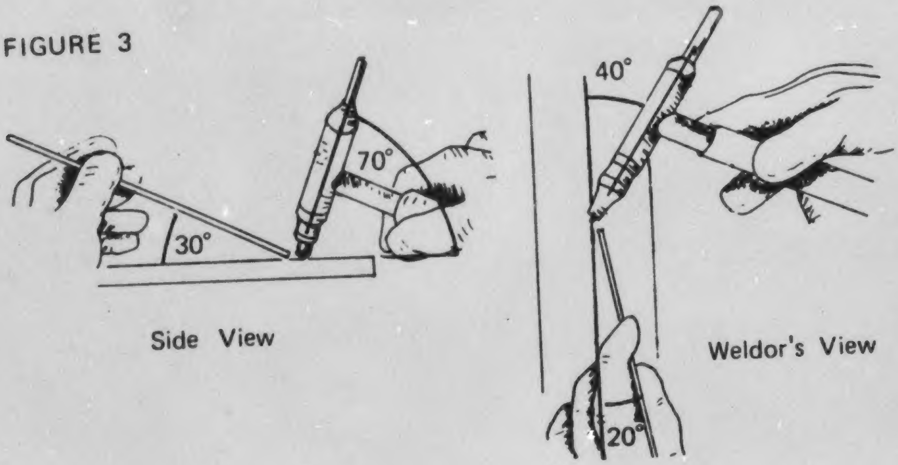
FIGURE 2



I. Tack each end of joint without filler rod (See Figure 2.)

J. Position torch at a 70° angle from table with a 40° side angle (Figure 3)

FIGURE 3

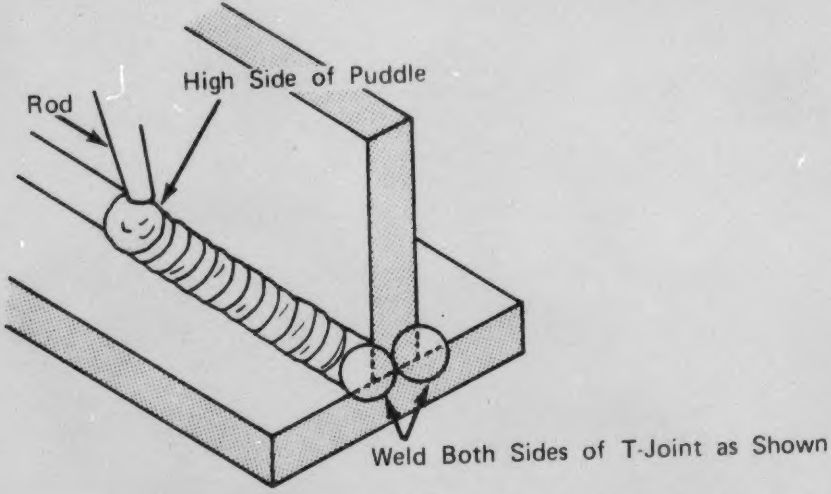


K. Hold rod at 30° angle from table with a 20° side angle (See Figure 3.)

L. Start arc and form puddle at end of joint

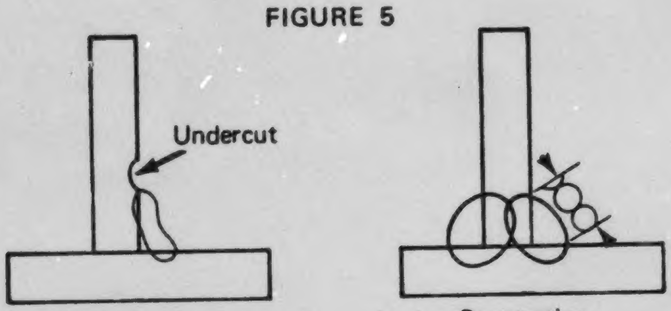
M. Dip filler rod in and out at high side of leading edge of puddle to prevent undercutting (Figure 4)

FIGURE 4



N. Travel at speed to produce a bead 2 1/2 to 3 times the diameter of electrode (Figure 5)

FIGURE 5



No Penetration

Penetration

Bead Face Should Be 2 1/2 - 3 Times Diameter of Electrode

O. Hold close arc to insure deep penetration and to prevent undercutting (See Figure 5.)

P. Inspect weld for undercutting and smooth even ripple (See Figure 5.)

Q. Submit to instructor for inspection

GAS TUNGSTEN ARC WELDING
UNIT IV

JOB SHEET #8--CONSTRUCT A T-JOINT FILLET WELD ON ONE-EIGHTH INCH ALUMINUM WITH FILLER ROD IN THE VERTICAL UP POSITION

I. Equipment and materials

A. GTAW power supply and required equipment

B. Personal protective equipment

C. Stainless steel wire brush (clean)

D. 1/8" aluminum filler rod

E. Pure tungsten electrode 3/32" green strip (See chart 3.)

(NOTE: Three-thirty-second inch electrode requires a 3/32" collet and collet body.)

F. Argon shielding gas 15-20 c.f.h.

G. Two pieces, 1/8" x 2" x 6" aluminum

II. Procedure

A. Clean aluminum with stainless wire brush to remove oxide coating

B. Check torch for the following

1. Nozzle (cup) size 3/8" inside diameter

a. Unburnt

b. Even end with no cracks or chips

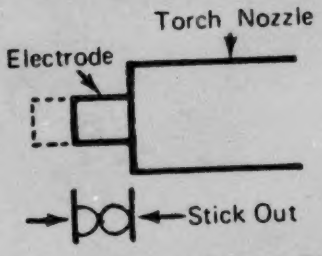
2. Correct collet and collet body (check)

3. Correct tungsten with the following

a. Round shiny end

b. Correct stick out (Figure 1)

FIGURE 1



1 1/2-2 Times Electrode Diameter

c. Finger tighten cap to secure tungsten

(NOTE: It may be helpful to extend electrode 1/16"-1/8" to aid weldor's view of puddle and increase penetration.)

C. Attach ground clamp

D. Set welding machine and turn on power

1. AC current

2. Current adjustment

a. Coarse adjustment--middle range 10-250

b. Fine adjustment--maximum

E. Set high frequency

1. Continuous operation

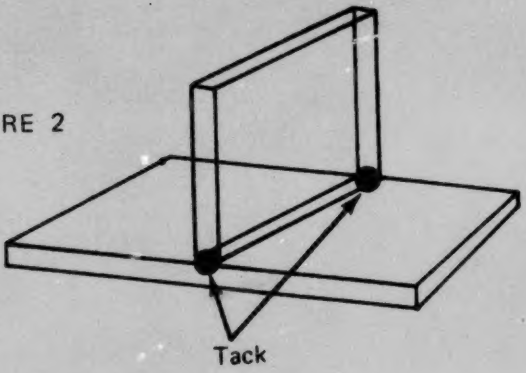
2. Rheostat to medium

F. Set shielding gas 15-20 c.f.h.

G. Set post purge to 15 seconds

H. Position two pieces of aluminum to form a T-joint (Figure 2)

FIGURE 2

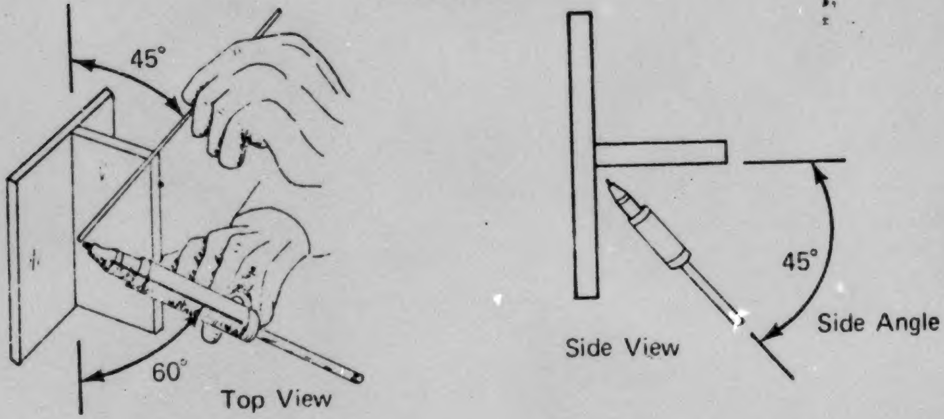


I. Tack each end of joint without filler rod (See Figure 2.)

J. Secure T-joint in vertical position

K. Center torch near bottom of joint holding a 45° side angle to each plate with a 60° angle from work (Figure 3)

FIGURE 3



Top View

Side View

L. Hold rod at a 45° angle to each plate with a 45° angle to metal (See Figure 3.)

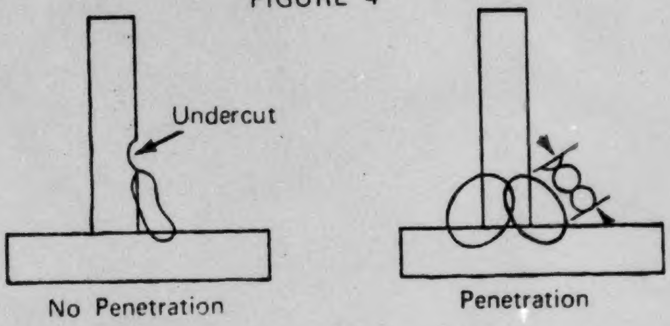
M. Start arc and rapidly form puddle at bottom of joint and center between plates

N. Dip filler rod in and out of leading edge of puddle being careful not to touch tungsten electrode

O. Bead should be 2 1/2 to 3 times diameter of tungsten

P. Hold close arc length to insure penetration to root of joint and to prevent undercut (Figure 4)

FIGURE 4



Bead Face Should Be 2 1/2 - 3
Times Diameter of Electrode

Q. Inspect weld for undercutting and smooth even ripple (See Figure 4.)

R. Submit to instructor for inspection

GAS TUNGSTEN ARC WELDING
UNIT IV

NAME______________________________

TEST

1. Match the terms on the right to their correct definition.

_____a. A device used by the welder to control welding current during the welding process

_____b. A thin film that forms on the surface of aluminum due to a reaction between the metal and oxygen in the air

_____c. A chucking device used to hold the tungsten in the torch

_____d. The science and technology of metals

_____e. An arc welding process wherein coalescence (fusion) is produced by heating with an arc between a non-consumable tungsten electrode and the base metal utilizing an inert gas, argon, or helium that shields the weld zone from contamination by oxygen and nitrogen in the air

_____f. A calibrated metering device used to regulate the flow of gases to the torch and measured in cubic feet per hour (c.f.h.)

_____g. A holding device for the collet

_____h. An attachment that fits on the end of the GTAW torch to direct the flow of shielding gas to the tungsten and weld zone

1. Gas tungsten arc welding
2. Inert shielding gas
3. Tungsten electrode
4. High frequency current
5. Aluminum oxide
6. Gas cup
7. Collet body (chuck)
8. Flowmeter
9. Foot control
10. Collet
11. Thermal conductivity
12. Metallurgy

_____i. A gas which will not combine with other gases used to surround the weld zone and prevent contamination of the weld by oxygen and nitrogen in the air

_____j. The characteristic of a metal to conduct heat throughout its thickness, width, and length

_____k. A high voltage low power source introduced into the A. C. weld current to start the arc and aid in oxide removal when welding aluminum

_____l. A practically non-consumable welding electrode used to create an intense arc between the tip of the electrode and the work

2. Match the GTAW components on the left to their proper application.

_____a. A.C. or D.C. welder machine

_____b. Drain

_____c. Inert gas supply

_____d. Flowmeter

_____e. Cooling water supply valve

_____f. Torch

_____g. Filler rod

_____h. Work material

_____i. Foot pedal

1. Metal to be repaired or bonded together

2. Used to measure the flow of gas to the torch

3. Used to control the flow rate of water to the torch

4. Provides the heat and shielding gas for welding

5. Used to prevent contamination of the weld zone

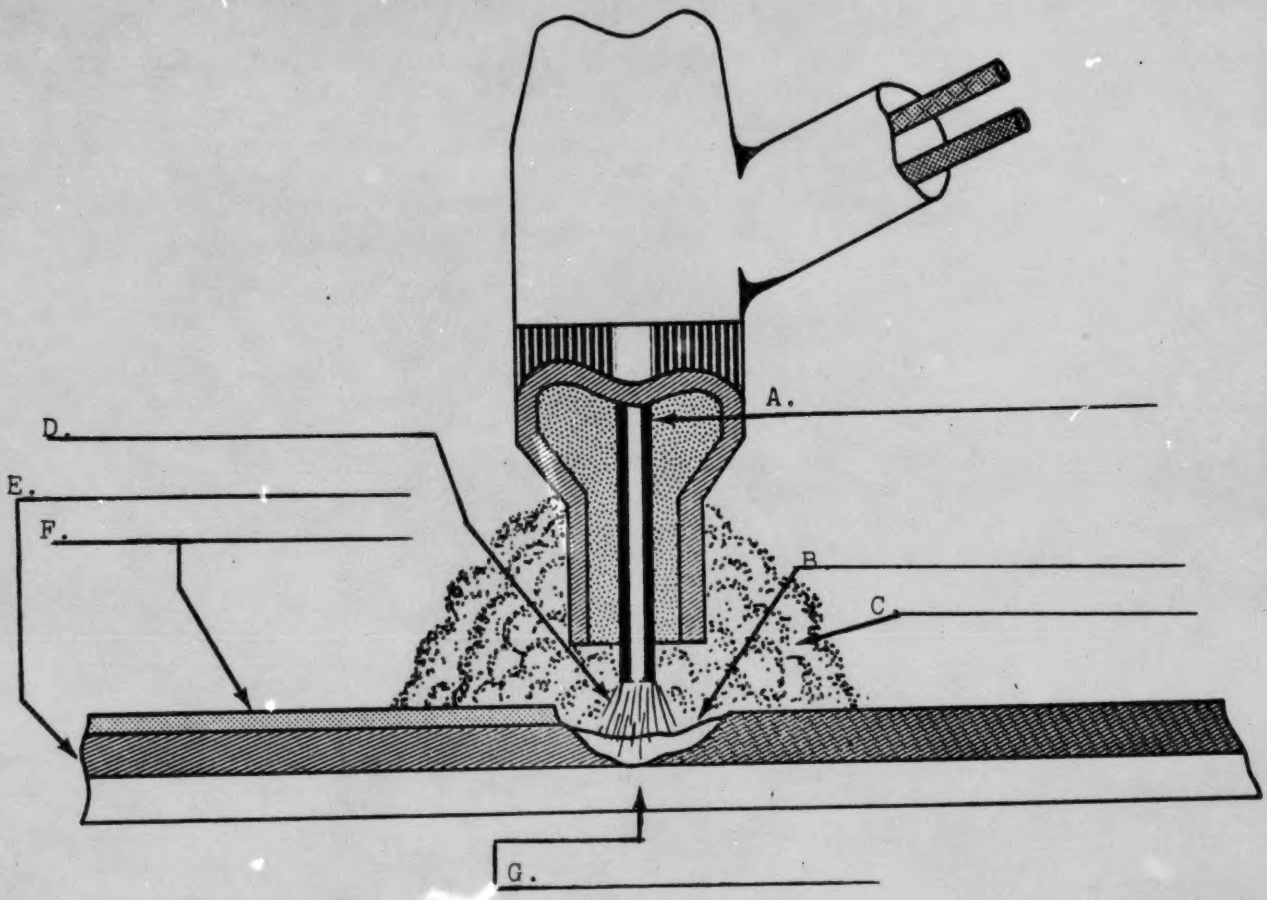
6. Outlet for water circulated during the welding process

7. Material used to form the bond between and/or on the base metals

8. Remote control of the welding process

9. Provides power and control of the welding process

3. Identify parts of the GTAW process.



4. Name three applications of the GTAW process.

a. ______________________________

b. ______________________________

c. ______________________________

5. Select five advantages of the GTAW process from the following examples. (Place an "X" by the correct example.)

_____a. Slag and spatter easily removed

_____b. Welder has very close control of welding current

_____c. Arc and weld puddle clearly visible to welder _____d. Makes poor root pass on carbon and stainless steel pipe

_____e. Minimum of distortion and stress with heat concentrated in a small area

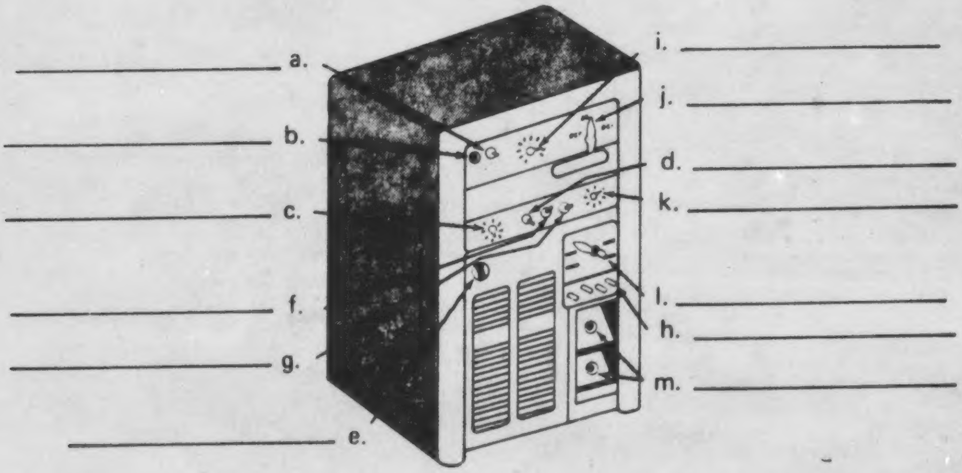
_____f. No flux used and no post cleaning required

_____g. Makes excellent root pass on carbon and stainless steel pipe

_____h. Wire feed motor is operated by constant DC power

_____i. Lends itself to assembly line use in the auto industry

6. Identify the major controls of the GTAW power supply from the drawing below.



7. Name the two types of welding current used most in GTAW welding.

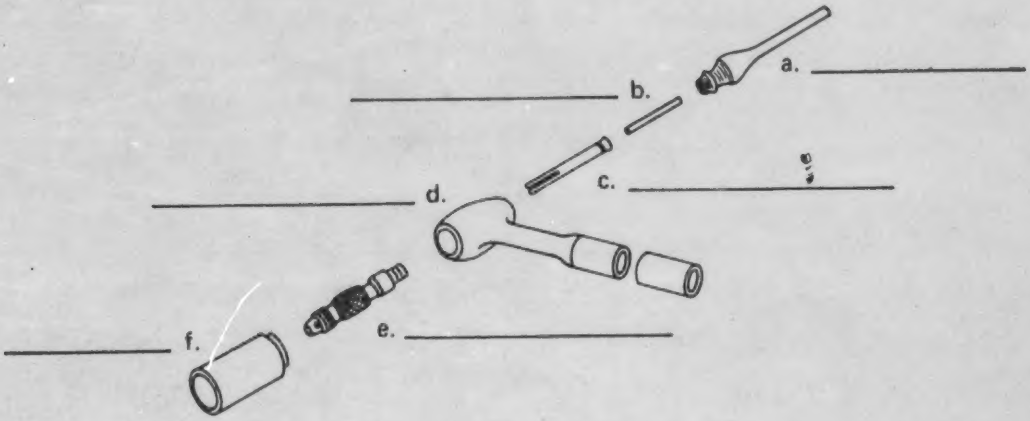
a. ____

____

b. ____

____

8. Identify the six major parts of a GTAW torch from the drawing below.



9. Name the color and application of two types of tungsten electrodes.

Type	Color	Application
a. Pure	______________	______________________
		______________________
b. Zirconiated	______________	______________________
		______________________

10. Aluminum

Match the following filler metals to the correct base metals.

_____1) Base metal 3003	a) 1100
_____2) Base metal 5052	b) 5356
_____3) Base metal 6061	c) 5652
_____4) Base metal 5005	d) 4043

11. List three major metallurgical factors to be considered when welding the following.

Aluminum

a. ____

____

b. ____

____

c. ____

____

12. Match the illustrations of poor welds with the cause of each.

_____a. Welding speed too fast

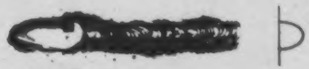
_____b. Welding current too high

_____c. Welding speed too slow

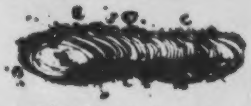
_____d. Arc too long (Voltage too high)

_____e. Welding current too low

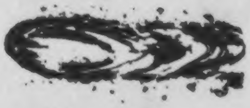
1.



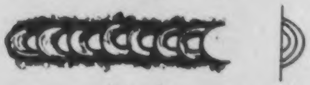
2.



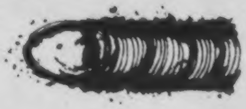
3.



4.



5.



13. Name five characteristics of a good weld.

a. ____

b. ____

c. ____

d. ____

e. ____

14. List the four characteristics of argon shielding gas.

a. Argon

1) ____

2) ____

3) ____

4) ____

15. Demonstrate the ability to:

a. Set up the GTAW power supply, select and adjust the correct current for aluminum, and shut down the equipment.

b. Clean aluminum both mechanically and chemically.

c. Run stringer beads on one-sixteenth inch aluminum in the flat position with filler rod.

d. Construct a square groove butt weld on one-eighth inch aluminum in the flat position with filler rod.

e. Construct a lap joint fillet weld on one-eighth inch aluminum in the horizontal position with filler rod.

f. Construct an outside corner fillet weld joint on one-eighth inch aluminum in the flat position without filler rod.

g. Construct a T-joint fillet weld on one-eighth inch aluminum in the horizontal position with filler rod.

h. Construct a T-joint fillet weld on one-eighth inch aluminum in the vertical up position with filler rod.

(NOTE: If the above activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

S-197-E

GAS TUNGSTEN ARC WELDING
UNIT IV

ANSWERS TO TEST

1. a. 9
   b. 5
   c. 10
   d. 12
   e. 1
   f. 8
   g. 7
   h. 6
   i. 2
   j. 11
   k. 4
   l. 3

2. a. 9
   b. 6
   c. 5
   d. 2
   e. 3
   f. 4
   g. 7
   h. 1
   i. 8

3. a. Tungsten electrode
   b. Molten weld pool
   c. Inert gas shield
   d. Arc Stream
   e. Base metal
   f. Filler rod
   g. Back up bar

4. a. Makes top quality welds possible on most all metals and alloys used in industry
   b. Welds possible in all positions through a wide range of metal thickness
   c. Used particularly for aluminum and its alloys (even on very thin sections)

5. b, c, e, f, g

6. a. Remote control switch (foot control)
   b. Remote control receptacle (foot control)
   c. Gas afterflow timer (post purge 0-60 seconds)
   d. Soft start

e. Power switch (On-Off)

f. Weld control switch--SMAW or GTAW welding

g. High frequency spark switch

  1) On-Off

  2) Start only

  3) Continuous

h. Gas and water connections

i. Fine adjustment current control

j. Polarity switch, DCRP, AC, DCSP

k. High frequency spark intensity rheostat

l. Current range selector

m. Ground and electrode terminals

7. a. Alternating current (AC) with high frequency for aluminum and magnesium

   b. Direct current straight polarity (DCSP) for mild and stainless steel

8. a. Cap

   b. Electrode

   c. Collet

   d. Torch body

   e. Collet holder (body)

   f. Gas nozzle (cup)

9.

	Color	Application
a.	Green	Aluminum or magnesium
b.	Brown	Aluminum or magnesium

10. a. Aluminum

  1) a

  2) c

    3) b

    4) d

11. Any three of the following:

    a. Melting point--Aluminum melts at 1220°F but requires higher welding currents than other metals due to its high thermal conductivity

    b. Aluminum oxide--Forms on the surface of aluminum when exposed to oxygen in the air; this oxide requires a temperature of 3700°F to melt or break down

    c. Heat colors--Aluminum shows no heat colors as it approaches the melting point

    d. Proper mechanical support--Since some aluminum alloys melt at 900°F care must be taken to support all areas subjected to the extreme heat of welding to prevent collapse, warping, and distortion

12. a. 5

    b. 2

    c. 4

    d. 1

    e. 3

13. a. Smooth edge

    b. Correct bead size

    c. Even penetration

    d. Even ripple

    e. Clean bright weld

14. a. Argon--Most popular gas for GTAW

       1) Easily obtainable at low cost

       2) Better shielding at lower flow rates (c.f.h.) than helium

       3) Easier arc starting than helium

       4) Better cleaning action when welding aluminum with AC current

15. Performance skills will be evaluated to the satisfaction of the instructor.

PIPE
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to list applications for different types of pipe used in solar system installation. The student should also be able to list advantages and disadvantages of plastic pipe, identify fittings, and select tools necessary to cut and install iron and plastic pipe. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with pipe to the correct definition or description.
2. List two applications for each type of pipe to be used in solar system installation.
3. Identify iron and C.P.V.C. fittings.
4. List four advantages and two disadvantages of C.P.V.C. pipe.
5. List four advantages and two disadvantages of galvanized pipe.
6. Discuss the three common methods of measuring pipe.
7. Select the tools necessary to cut and thread iron pipe.
8. Match fourteen procedures in cutting and threading iron pipe.
9. Select the tools necessary to make proper joints with P.V.C. or C.P.V.C. pipe.
10. Match nine procedures for installing P.V.C. or C.P.V.C. pipe.
11. Match statements on drying time of P.V.C. cement.

12. Demonstrate the ability to:

    a. Identify fittings by type and size.

    b. Identify the brass fittings necessary to connect a collector and drain valve piping to a storage tank.

    c. Determine the copper and C.P.V.C. pipe fittings necessary to connect a return line from a flat plate collector to a storage tank.

PIPE
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Demonstrate cutting and threading pipe.

   G. Demonstrate cutting and glueing P.V.C.

   H. Have students look up parts in a catalog.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete assignment sheets.

   D. Look up parts in a catalog to become familiar with how to order parts.

   E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Iron Pipe Fittings

      2. TM 2--Brass Fittings

3. TM 3--C.P.V.C. Fittings

4. TM 4--Tools for Cutting and Threading Iron Pipe

5. TM 5--Tools for Making P.V.C. or C.P.V.C. Joints

6. TM 6--Drying Time of P.V.C. Cement

D. Assignment sheets

1. Assignment Sheet #1--Identify Fittings by type and size

2. Assignment Sheet #2--Identify the Brass Fittings Necessary to Connect a Collector and Drain Valve Piping to a Storage Tank

3. Assignment Sheet #3--Determine the C.P.V.C. Pipe Fittings Necessary to Connect a Return Line From a Flat Plate Collector to a Storage Tank

E. Answers to assignment sheets

F. Test

G. Answers to test

II. Reference:

Slater, Harry. Related Information Plumbing. Volume 1 and 2. Albany, New York: Delmar Publishers, 1958.

PIPE
UNIT I

INFORMATION SHEET

I. Terms and definitions or descriptions

  A. Galvanize--To coat metal with zinc in order to prevent rusting

  B. P.V.C.--Rigid thermoplastic pipe

  (NOTE: P.V.C. is the abbreviation for polyvinyl chloride.)

  C. C.P.V.C.--Rigid thermoplastic pipe

  (NOTE: C.P.V.C. is the abbreviation for chlorinated polyvinyl chloride.)

  D. Nipple--Short piece of pipe twelve inches or less in length

  E. Dope--Thick lead base substance which is applied to pipe threads to help seal the joint

  F. F.P.T.--Female Pipe Taper

  G. M.P.T.--Male Pipe Taper

  H. Cast fittings--Heavy steel pipe fittings that are formed in a mold

  (NOTE: These fittings are generally referred to as malleable iron fittings.)

II. Pipe application in the solar trade

  A. Galvanized iron pipe

    1. Cold water supply lines

    2. Hot water supply lines

  B. Copper pipe

    1. Cold water supply lines

    2. Hot water supply lines

3. Safety valve release lines
4. Collector loop lines
5. Absorber's for collector plates

C. P.V.C. pipe

1. Cold water supply lines

D. C.P.V.C.

1. Hot water supply lines
2. Collector loop supply and return lines
3. Safety valve release lines

III. Pipe fittings (Transparency 1)

A. Iron fittings

(NOTE: Iron fittings are used on galvanized iron pipe.)

1. 90° ell
2. Tee
3. 45° ell
4. 90° street ell
5. Union

(NOTE: When connecting galvanized pipe to any other type of pipe, a special union must be used to prevent a corrosive action. This union is called an insulated union.)

6. Coupling
7. Reducer
8. Flange
9. Bushing
10. Cap
11. Plug
12. Nipple

B. Brass fittings (Transparency 2)

(NOTE: Brass fittings are used on copper pipe.)

1. Nipple
2. 90° ell
3. Street ell
4. Tee
5. Plug
6. Bushing

C. C.P.V.C. fittings (Transparency 3)

(NOTE: C.P.V.C. fittings are used on C.P.V.C. pipe for hot fluid applications to 210° F.)

1. 90° ell
2. 45° ell
3. Tee
4. Male adapter
5. Female adapter
6. Coupling
7. Bushing
8. Cap
9. 90° ell (C.P.V.C. to pipe)

IV. Advantages and disadvantages of C.P.V.C. pipe

A. Advantages

1. Light weight

2. Easy to install

3. Lower cost than copper or steel

4. Requires no special tools

B. Disadvantages

1. Applications limited to 210° F

2. Supports must be closer at elevated temps

3. Lacks mechanical strength of copper or iron pipe

V. Advantages and disadvantages of galvanized pipe

A. Advantages

1. Coated to resist rust

2. Will handle high pressures liquids

3. Will handle high temperature liquids

4. Has high tensile strength

B. Disadvantages

1. Requires special tools to install

2. Will rust if protective coating is damaged

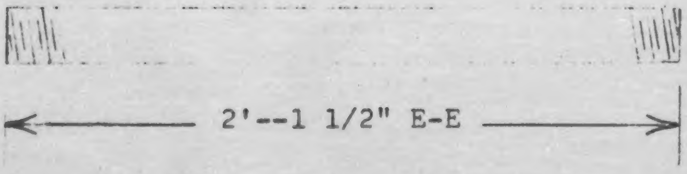
VI. Methods of measuring pipe

A. End to end

1. Straight length of pipe

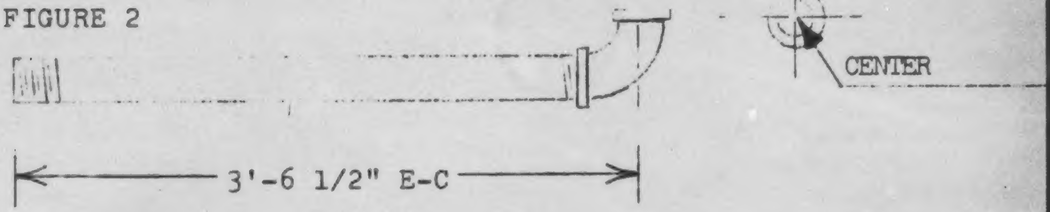
2. Measure pipe without fittings (Figure 1)

FIGURE 1



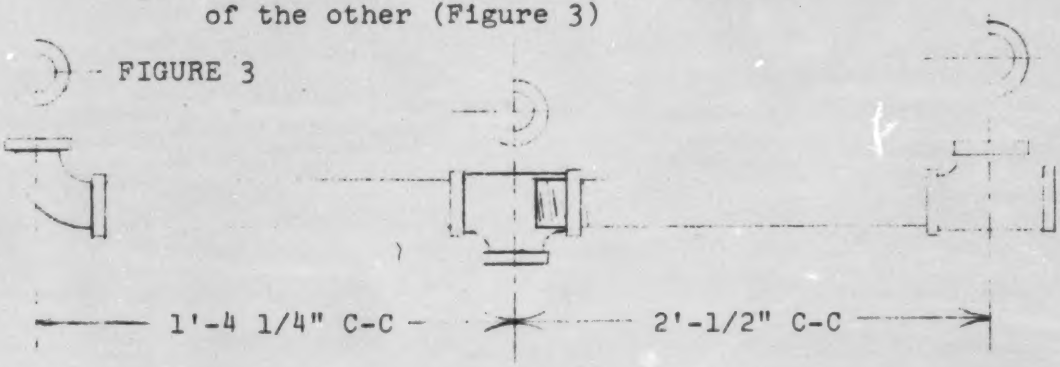
B. End to center
   1. Straight length of pipe
   2. Tighten a fitting on one end
   3. Measure from end to center of fitting (Figure 2)

FIGURE 2



C. Center to center
   1. Straight length of pipe
   2. Tightened fitting on each end
   3. Measure from center of one fitting to the center of the other (Figure 3)

FIGURE 3



VII. Tools necessary to cut and thread iron pipe (Transparency 4)
   A. Cutter
   B. Reamer
   C. Pipe vise
   D. Dies
   E. Die stock
   F. Oil can

VIII. Cutting and threading iron pipe
   A. Secure pipe in vise
   B. Cut the pipe

(NOTE: Cut end must be square.)

C. Ream inside of pipe to remove burrs

D. Lightly file outside cut edge

E. Inspect and clean dies before threading

F. Check cutting edges for sharpness

G. Be sure dies are in the die stock properly

H. Center die on pipe

I. Turn die slowly in a clockwise direction

J. Apply cutting oil while threading

(NOTE: A good grade of cutting oil eases cutting and cools die threads.)

K. Determine length of the threaded portion

(NOTE: This can be determined by using Table 1.)

L. Remove die by turning counterclockwise

M. Clean chips from threads

N. Clean chips from dies

(CAUTION: Do not remove chips with compressed air.)

TABLE 1

SPECIFICATIONS FOR THREADING PIPE

Nominal Size of Pipe in Inches	Approx. Length of Threads in Inches	Approx. Number of Threads To Be Cut
1/2	3/4	10
3/4	3/4	10
1	7/8	10
1 1/4	1	11
1 1/2	1	11
2	1	11
2 1/2	1 1/2	12
3	1 1/2	12
4	1 2/3	13

IX. Tools necessary for proper P.V.C. or C.P.V.C. Joints (Transparency 5)

A. Miter box

B. Miter saw

C. Clean towels

D. Cleaner

E. Knife

F. Cement

G. Natural bristle or nylon brush

X. Steps for installing P.V.C. or C.P.V.C. pipe

A. Cut pipe square

B. Remove burrs inside and out

C. Clean pipe with clean towel

D. Check fit of pipe into fitting

E. Clean pipe with cleaner

F. Apply a coat of cement with brush

G. Put fitting on pipe immediately after applying cement

(NOTE: Fitting must be turned in the proper direction when it is placed on the pipe because it can not be moved once it comes into contact with the cement.)

H. Hold pressure against fitting momentarily

I. Don't disturb pipe until dry (Transparency 6)

(NOTE: Drying time is dependent on the ambient temperature.)

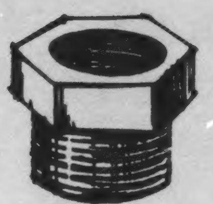
XI. Drying time for P.V.C. cement (Transparency 6)

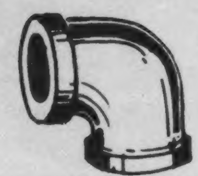
A. Drying time for P.V.C. or C.P.V.C. cement will increase as the ambient temperature drops.

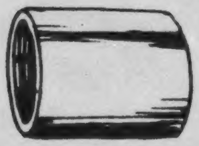
B. Drying time decreases as the ambient temperature increases.

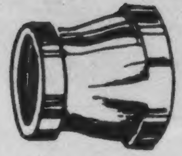
(NOTE: Care should be exercised in handling pipe during the drying period.)

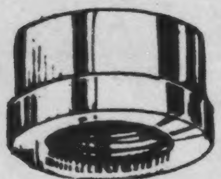
Iron Pipe Fittings

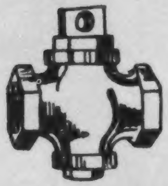

Bushing

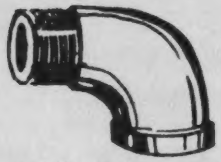

90° ELL

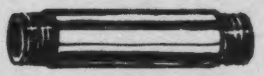

Coupling

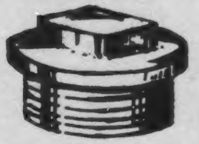

Reducer

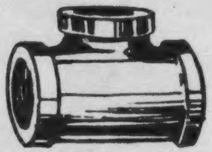

Cap

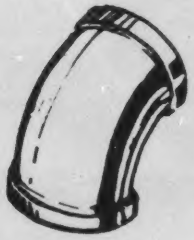

Gas Cock

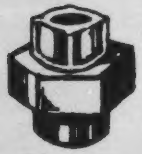

90° Street ELL

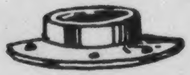

Nipple


Plug


Tee


45° ELL

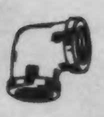

Union


Flange

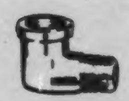
TM - 1

S-13-F

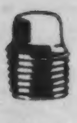
Brass Fittings



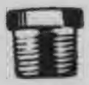
90° ELL



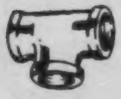
Street ELL



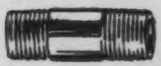
Plug



Bushing

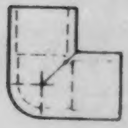


Tee

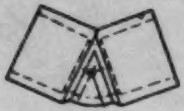


Nipple

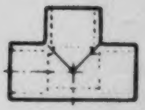
C.P.V.C. Fittings



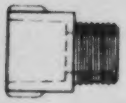
90° ELL



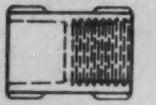
45° EL



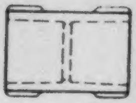
Tee



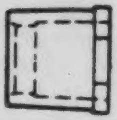
Male Adapter



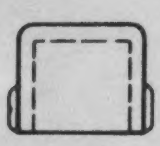
Female Adapter



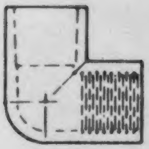
Coupling



Bushing

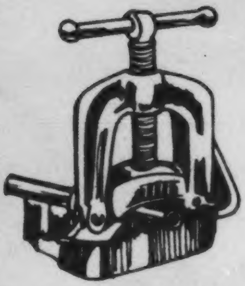


Cap

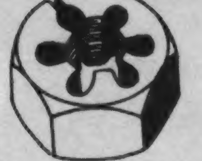


90° EL
C. P.V.C. to Pipe

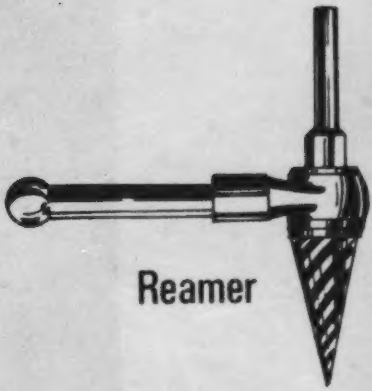
Tools For Cutting and Threading Iron Pipe



Pipe Vise

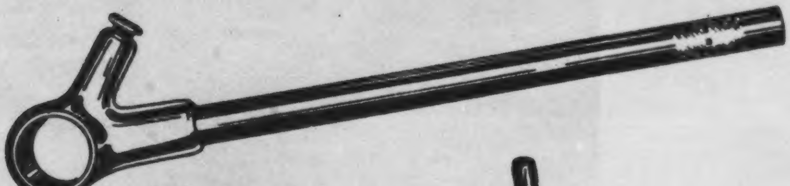


Die

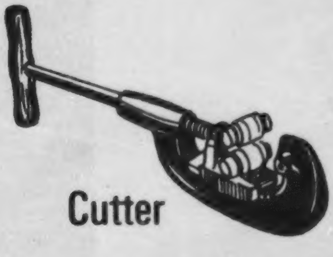


Reamer

Oil Can



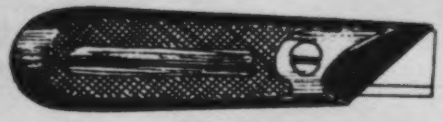
Die Stock



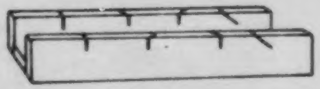
Cutter

Tools For Making P.V.C. or C.P.V.C. Joints

Cement

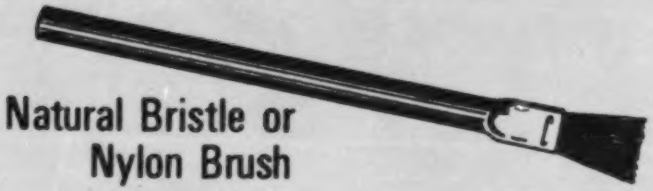


Knife

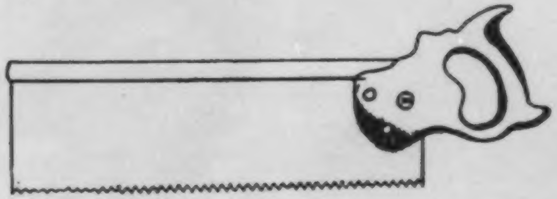


Miter Box

Cleaner



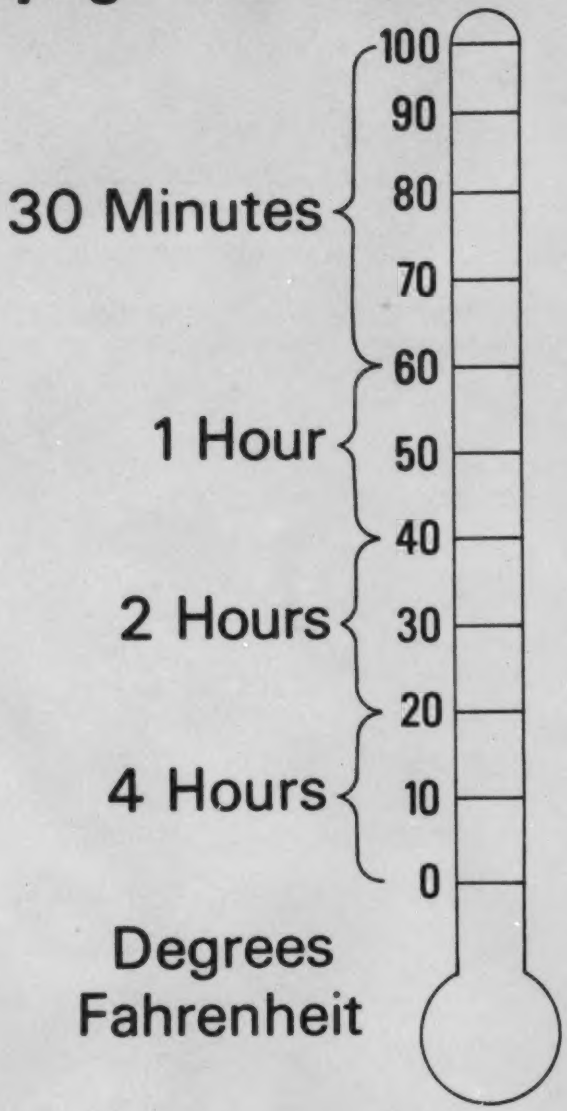
Natural Bristle or
Nylon Brush



Miter Saw

Clean Towels

Drying Time of P.V.C. Cement



PIPE
UNIT I

ASSIGNMENT #1--IDENTIFY FITTINGS BY TYPE AND SIZE

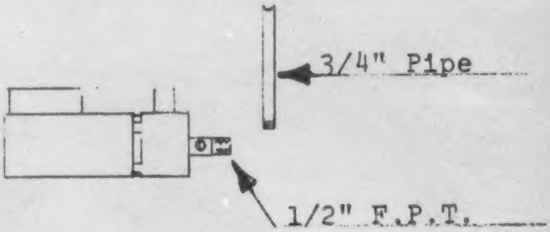
Ells, street ells, and tees are available in reducing sizes. When ordering a reducing fitting, give the larger size first.

Example: To connect two pieces of 1/2" pipe to a 3/4" line it would require a 3/4" x 1/2" x 1/2" tee.

Give the fitting type and size in proper order for the following:

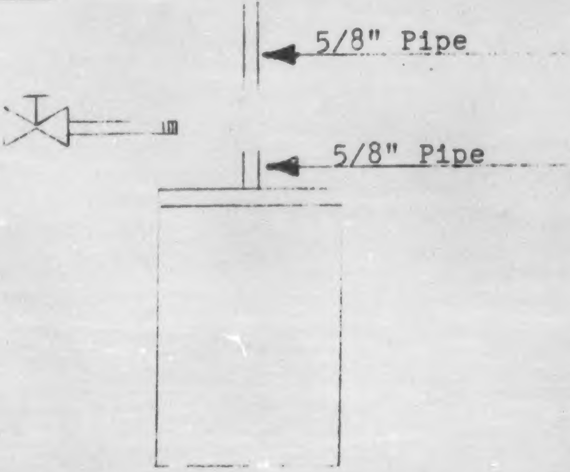
1. A 3/4" galvanized pipe must make a 90° turn and connect into a circulation pump with a 1/2" F.P.T. opening.

   Answer____________________



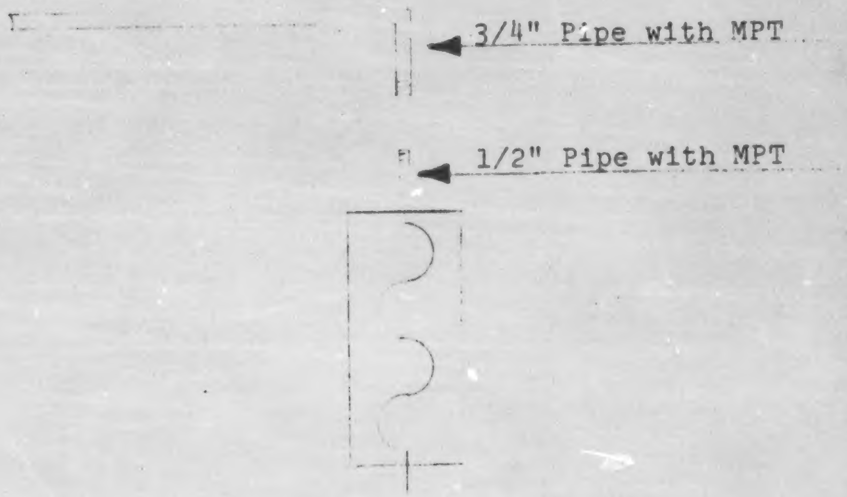
2. The return line in a collector loop is 5/8" copper. A boiler drain with 1/2" M.P.T. must be installed 12" from storage tank.

   Answer____________________



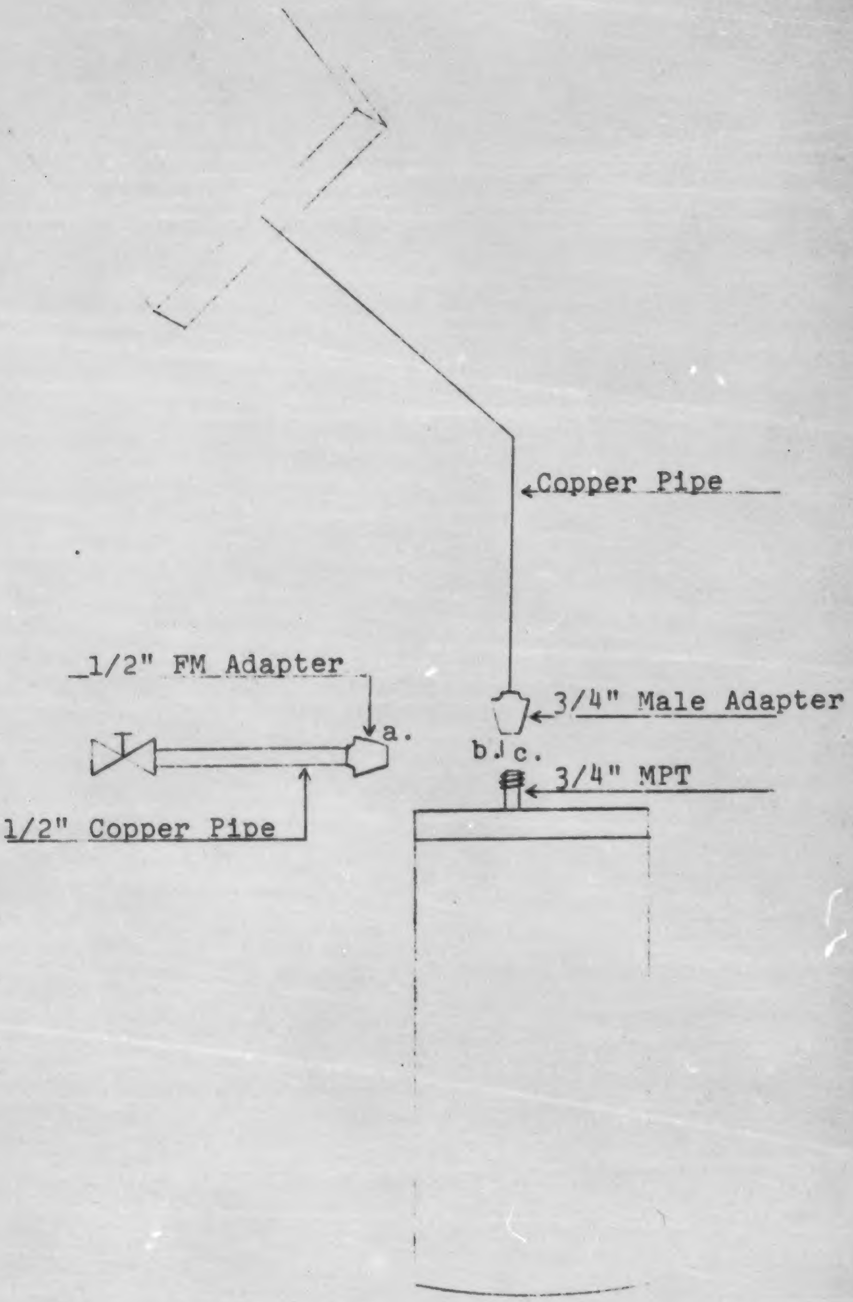
3. The outlet fitting on a heat exchanger is 1/2" male pipe thread that must connect to a 3/4" galvanized pipe.

Answer______________________



PIPE
UNIT I

ASSIGNMENT #2--IDENTIFY THE BRASS FITTINGS NECESSARY TO CONNECT THE COLLECTOR AND DRAIN VALVE PIPING TO THE STORAGE TANK



Answers

a. ____________

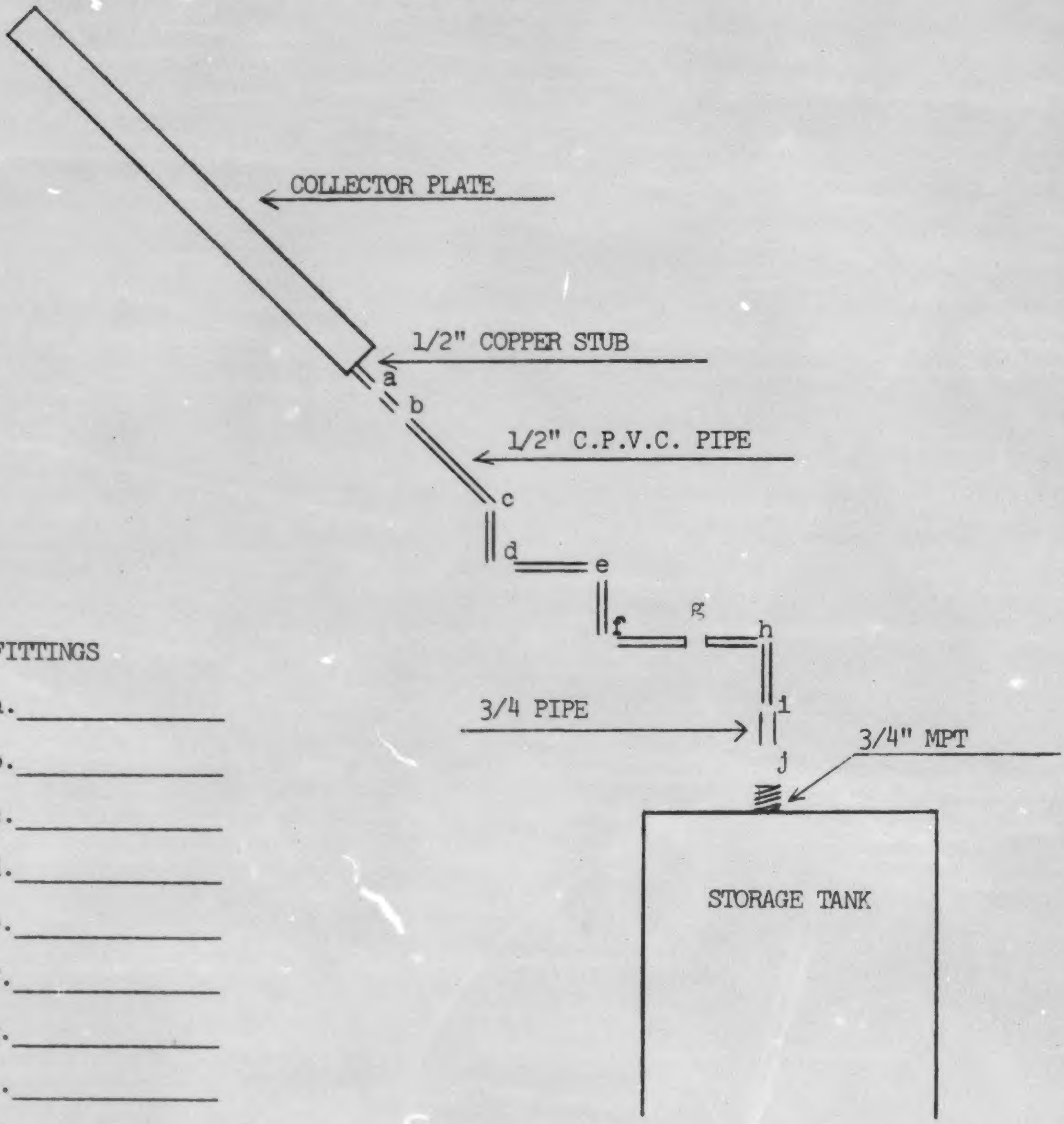
b. ____________

c. ____________

PIPE
UNIT I

ASSIGNMENT SHEET #3--DETERMINE THE COPPER AND C.P.V.C. PIPE FITTINGS NECESSARY TO CONNECT A RETURN LINE FROM A FLAT PLATE COLLECTOR TO A STORAGE TANK

Make a list of the required copper and C.P.V.C. fittings necessary to connect the return line in the system below.



FITTINGS

a.________________

b.________________

c.________________

d.________________

e.________________

f.________________

g.________________

h.________________

i.________________

j.________________

PIPE
UNIT I

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. Street ell--3/4" FPT x 1/2" MPT
2. Reducing Tee--5/8" x 5/8" x 1/2"
3. Coupling--3/4" x 1/2" reducing

Assignment Sheet #2

a. Nipple--1/2" shoulder

b. Bushing--3/4" x 1/2" reducing

c. Tee--3/4" x 3/4" x 3/4"

Assignment Sheet #3

a. Female adapter (copper)

b. Male adapter (C.P.V.C.)

c. 45° ell

d. 90° ell

e. 90° ell

f. 90° ell

g. Coupling

h. 90° ell

i. Reducing coupling

j. Female adapter

PIPE
UNIT I

NAME______________________________

TEST

1. Match the terms on the right to the correct definitions or descriptions.

_____a. Rigid plastic pipe

_____b. To coat metal with zinc in order to prevent rusting

_____c. Short piece of pipe twelve inches or less in length

_____d. Heavy steel pipe fittings that are formed in a mold

_____e. Thick lead base substance which is applied to pipe threads to help seal the joint

_____f. Female pipe taper

_____g. Refers to wrought iron or steel pipe

_____h. Male pipe taper

1. Long pipe
2. Nipple
3. Dope
4. P.V.C. or C.P.V.C.
5. Galvanize
6. M.P.T.
7. F.P.T.
8. Cast fittings

2. List two applications for each type of pipe to be used in solar systems installation.

a. Copper pipe

1)____

2)____

b. Galvanized iron pipe

1)____

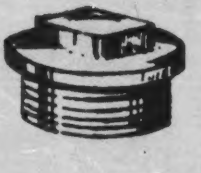
2)____

c. C.P.V.C. pipe

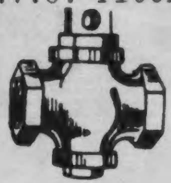
1)____

2)____

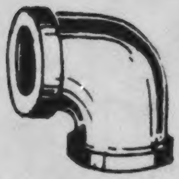
3. Identify the iron and C.P.V.C. fittings only



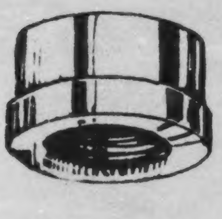
a. ____________



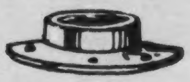
b. ____________



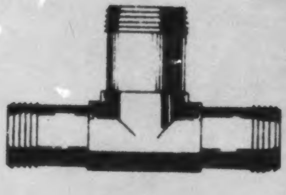
c. ____________



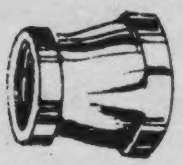
d. ____________



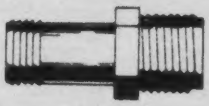
e. ____________



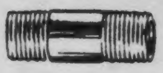
f. ____________



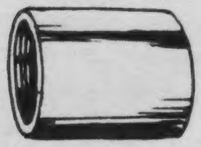
g. ____________



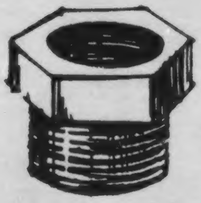
h. ____________



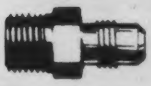
i. ____________



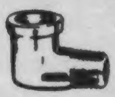
j. ____________



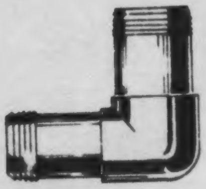
k. ____________



l. ____________

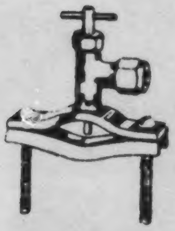


m. ____________

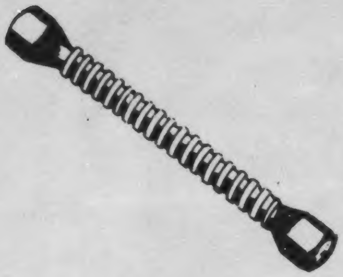


n. ____________

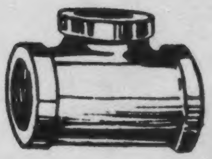
o. ____________



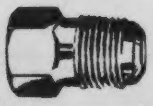
p. ____________________



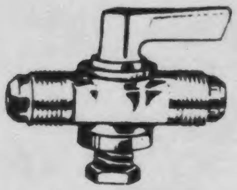
q. ____________________



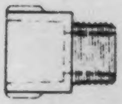
r. ____________________



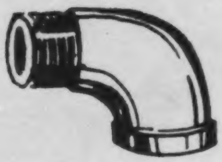
s. ____________________



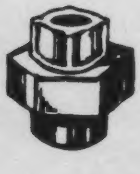
t. ____________________



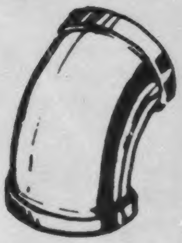
u. ____________________



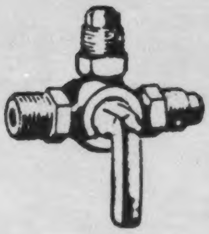
v. ____________________



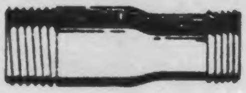
w. ____________________



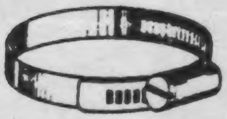
x. ____________________



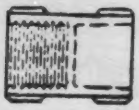
y. __________________________



z. __________________________



aa. __________________________



bb. __________________________

S-36-F

4. List four advantages and two disadvantages of C.P.V.C.-plastic pipe.

a. Advantages

1) ____________________

2) ____________________

3) ____________________

4) ____________________

b. Disadvantages

1) ____________________

2) ____________________

5. List four advantages and two disadvantages of galvanized pipe.

a. Advantages

1) ____________________

2) ____________________

3) ____________________

4) ____________________

b. Disadvantages

1) ____________________

2) ____________________

6. Discuss the three common methods of measuring pipe.

A. End to end method

1) ____________________

2) ____________________

B. End to center

1) ____________________

2) ____________________

3) ____________________

C. Center to center

1) ______________________________

2) ______________________________

3) ______________________________

7. Select the tools necessary to cut and thread iron pipe by placing an "X" in the appropriate blank. ✓

_____a. Pipe vise

_____b. Oil can

_____c. Pipe wrench

_____d. Reamer

_____e. Cutter

_____f. Die stock

_____g. Flaring tool

_____h. Dies

8. Match the fourteen procedures on the right to their proper order in cutting and threading iron pipe.

Steps

a._____

b._____

c._____

d._____

e._____

f._____

g._____

h._____

i._____

j._____

k._____

1. Cut the pipe
2. Center die on pipe
3. Secure pipe in vise
4. Apply cutting oil while threading
5. Ream inside of pipe
6. Clean chips from dies
7. Lightly file outside cut edge
8. Remove die by turning counterclockwise
9. Inspect and clean dies before threading
10. Check cutting edges for sharpness

l._____	11. Clean chips from threads
m._____	12. Be sure dies are in the stock properly
n._____	13. Determine length of the threaded portion
	14. Turn die slowly in a clockwise direction

9. Select the tools necessary to make proper joints with P.V.C. or C.P.V.C. pipe by placing an "X" in the appropriate blank.

_____a. Pipe vise

_____b. Knife

_____c. Miter saw

_____d. Cement

_____e. Hammer

_____f. Natural bristle or nylon brush

_____g. Pipe wrench

_____h. Miter box

_____i. Clean towels

10. Match the procedures on the right to their proper order for installing P.V.C. or C.P.V.C. pipe.

a._____	1. Apply a coat of cement with brush
b._____	2. Check fit of pipe into fitting
c._____	3. Cut pipe square
d._____	4. Remove burrs inside and out
e._____	5. Do not disturb pipe until dry
f._____	6. Clean pipe with C.P.V.C. cleaner
g._____	7. Clean pipe with clean towel
h._____	8. Hold pressure against fitting momentarily
i._____	

9. Put fitting on pipe immediately after applying cement

11. Match the statements on the right to their proper application on drying time for P.V.C. cement.

_____a. Drying time increases

_____b. Drying time decreases

1. High ambient temperature
2. Average ambient temperature
3. Low ambient temperature
4. On sunny days

12. Demonstrate the ability to:

a. Identify pipe fittings by type and size.

b. Identify brass fittings necessary to connect a collector and drain valve piping to a storage tank.

c. Determine the copper and C.P.V.C. pipe fittings necessary to connect a return line from a flat plate collector to a storage tank.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

PIPE
UNIT I

ANSWERS TO TEST

1. a. 4 e. 3
b. 5 f. 7
c. 2 g. 1
d. 8 h. 6

2. Any two of the following under each type of pipe:
   a. Copper pipe
      1) Cold water supply lines
      2) Hot water lines
      3) Collector fluid transport lines
      4) Safety valve release line
   b. Galvanized iron pipe
      1) Hot water supply line
      2) Cold water supply line
      3) Collector drain down line
   c. C.P.V.C.
      1) Hot water supply lines
      2) Collector loop lines for flat plate collectors
      3) Safety valve release line

3. a. Iron-plug
   c. Iron-90° ell (elbow)
   d. Iron-cap
   e. Iron-Flange
   g. Iron-reducing coupling
   j. Iron-coupling

k. Iron-bushing

m. Iron-street ell (elbow)

r. Iron-tee

u. C.P.V.C.-male adapter

v. Iron-street ell (elbow)

w. Iron-union

x. Iron-45° ell (elbow)

bb. C.P.V.C.-female adapter

4. a. Advantages
   1) Light weight
   2) Easy to install
   3) Lower cost than copper or steel
   4) Requires no special tools

   b. Disadvantages - Any two of the following:
   1) Applications limited to 210° F
   2) Supports must be closer at elevated temps
   3) Lacks mechanical strength of copper or iron pipe

5. a. Advantages
   1) Coated to resist rust
   2) Will handle high pressure liquids
   3) Will handle high temperature liquids
   4) Has high tensile strength

   b. Disadvantages
   1) Requires special tools to install
   2) Will rust if protective coating is damaged

6. Discussion should include:
   - a. End to end
     - 1) Straight length of pipe
     - 2) Measure pipe without fittings
   - b. End to center
     - 1) Straight length of pipe
     - 2) Tighten a fitting on one end
     - 3) Measure from end to center of fitting
   - c. Center to center
     - 1) Straight length of pipe
     - 2) Tightened fitting on each end
     - 3) Measure from center of one fitting to the center of the other

7. a, b, d, e, f, h

8. a. 3

b. 1

c. 5

d. 7

e. 9

f. 10

g. 12

h. 2

i. 14

j. 4

k. 13

l. 8

m. 11

n. 6

9. b, c, d, f, h, i

10. a. 3

b. 4

c. 7

d. 2

e. 6

f. 1

g. 9

h. 8

i. 5

11. a. 3

b. 1

12. Performance skills evaluated to the satisfaction of the instructor.

PIPE FITTINGS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify pipe fittings used in the installation of residential solar hotwater systems. The student should also be able to designate specific applications for these fittings. This knowledge will be evidenced by correctly performing the procedures outlined on the assignment sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to;

1. Match terms associated with pipe fittings to the correct definitions or descriptions.
2. Match materials used to make pipe fittings with specific types.
3. Match the name of basic fittings to their proper application.
4. Identify assorted copper pipe fittings.
5. Demonstrate the ability to:
    a. List copper fittings necessary to install components in a solar collector loop.
    b. Select pipe fittings necessary to connect the supply line for a flat plate collector loop.
    c. Identify fittings from a sketch of a piping system.

PIPE FITTINGS
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Conduct tour of plumbing supply storage.

   G. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete assignment sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Basic Plumbing Bends

      2. TM 2--Basic Plumbing Unions and Couplings

      3. TM 3--Basic Plumbing Fittings

      4. TM 4--Copper Fittings

D. Assignment Sheets

   1. Assignment Sheet #1--List Copper Fittings Necessary to Install Components in a Solar Collector Loop

   2. Assignment Sheet #2--Select Fittings Necessary to Connect the Supply Line for a Flat Plate Collector Loop

   3. Assignment Sheet #3--Identify Fittings from a Sketch of a Piping System

E. Answers to assignment sheets

F. Test

G. Answers to test

II. References:

A. Blankenbaker, E. Keith. Modern Plumbing. South Holland, IL: Goodheart-Willcox, 1978.

B. Naval Training Command: Rate Training Manual, Utilitiesman 3 and 2. Washington, D.C.: U.S. Government Printing Office, 1973.

C. National Plumbing Code Illustrated. St. Petersburg, FL: Manus Publishing, 1973.

III. Additional references:

A. Building Construction. Columbia, MO: University of Missouri-Columbia/Instructional Materials Laboratory, 1978.

B. Ludwig, Oswald A., and Willard McCarthy and Victor Repp. Metalwork Technology and Practice. Bloomington, IL: McKnight Publishing, 1975.

C. Manufacturers catalogs

PIPE FITTINGS
UNIT II

INFORMATION SHEET

I. Terms and definitions or descriptions

- A. Fittings--Those parts of the piping system which are used to join pipes and tubes

  (NOTE: Valves are not usually considered fittings.)

- B. Adapter--Type of fitting which joins pipes of different materials
- C. Bushing--Fitting used to reduce size
- D. Joint--The connection of pipe to fitting or any combination of fittings and pipes
- E. Pipe joint compound--A substance used on threaded joints to help make them tight, to lubricate them, and to fill in imperfections
- F. FPT--Female pipe thread
- G. MPT--Male pipe thread
- H. Malleable--Lack of brittleness
- I. Rigid--Inflexible
- J. Thread tape--Substitute for pipe compound

  (NOTE: Thread tape is often Teflon tape.)

II. Uses, types, and properties of materials used to make pipe fittings

- A. Copper
  - 1. Uses
    - a. Water services and distribution
    - b. Drainage (above ground)
    - c. Vents
    - d. Gas (LPG)

2. Types
    a. Wrought
    b. Cast (Brass)
3. Properties
    a. Fairly malleable
    b. Rigid
    c. Light weight, needs light support

B. Plastic

1. Uses
    a. Vents
    b. Water services
    c. Heat transfer fluid service
2. Types
    a. P.V.C.-Polyvinyl chloride
    b. C.P.V.C.-Chlorinated polyvinyl chloride

       (NOTE: Check other types of plastic in your locality.)
3. Properties
    a. Very malleable
    b. P.V.C. is fairly rigid
    c. C.P.V.C. is fairly rigid
    d. Light weight, needs light support

C. Steel Pipe

1. Uses
    a. Vents (galvanized)
    b. Water service and distribution (galvanized)
2. Types
    a. Galvanized

3. Properties
   a. Fairly malleable
      (NOTE: Threads can be easily damaged.)
   b. Rigid
   c. Heavy, needs strong support or base
   d. Tends to rust

III. Basic Fittings

A. Plumbing bends (Transparency 1)
   1. Male street elbow (copper)
   2. Female adapter elbow (copper)
   3. Drop-ear elbow (copper to FIP)

B. Unions and couplings (Transparency 2)
   1. Unions
      a. Gasket type (malleable galvanized iron)
      b. Dielectric (copper)
      c. Straight (copper to copper)
      d. Ground joint (malleable galvanized iron)
   2. Couplings
      a. Straight
      b. Adapter-male to female
      c. Reducing

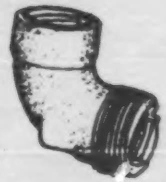
C. Basic caps and plugs (Transparency 3)
   1. Caps
      a. Cast iron
   2. Plugs
      a. Solid

- D. Basic bushings and nipples (Transparency 3)
  - 1. Bushings
    - a. Copper
    - b. Malleable cast iron
  - 2. Nipples
    - a. Close
    - b. Shoulder
    - c. Long

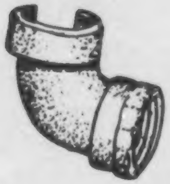
IV. Copper Fittings (Transparency 4)

- A. Couplings
  - 1. Staked stop
  - 2. Rolled stop
  - 3. No stop
  - 4. Reducing
- B. Caps
- C. Adapters
  - 1. Solder x F.P.T.
  - 2. Solder x M.P.T.
- D. Unions
  - 1. Solder x M.P.T.
  - 2. Solder x solder
- E. Tees
- F. Ells
  - 1. 45°
  - 2. 90° short radius
  - 3. 90° long radius

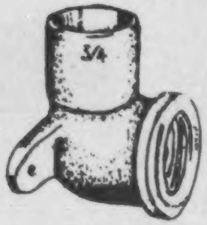
Basic Plumbing Bends



Male Street Elbow
(copper)



Female Adapter Elbow
(copper)



Drop-Ear Elbow
(copper to fip)

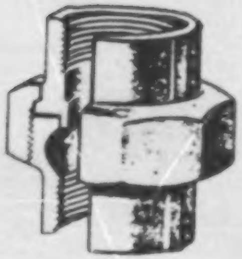
Used with permission of Nibco, Inc., Elkart, Indiana

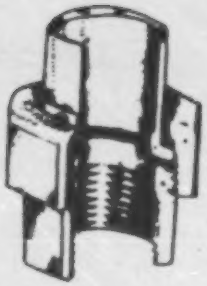
P 233 D

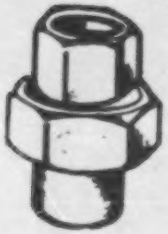
TM-1

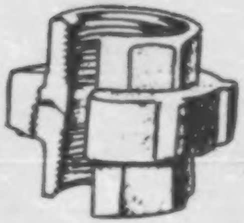
Basic Plumbing Unions and Couplings

Unions

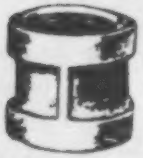

Gasket Type
(Malleable Galvanized Iron)

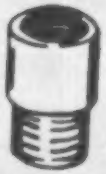

Dielectric
(Copper)

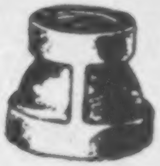

Straight
(Copper to Copper)


Ground Joint
(Malleable Galvanized Iron)

Couplings


Straight


Adapter
Male to Female


Reducing

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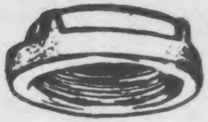
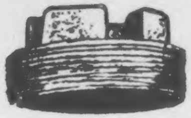
Basic Plumbing Fittings

Basic Caps and Plugs

Caps


Cast Iron

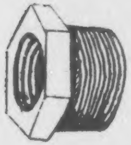
Plugs


Solid

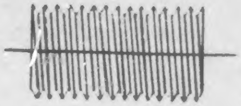
Basic Bushings and Nipples

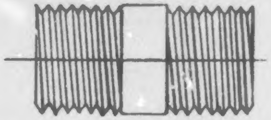
Bushings

Copper


Malleable cast iron

Nipples


Close


Shoulder

Long

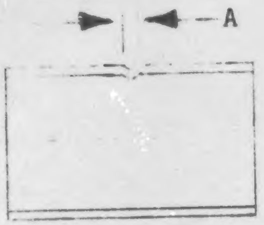
S-57-F

TM-3

COPPER FITTINGS

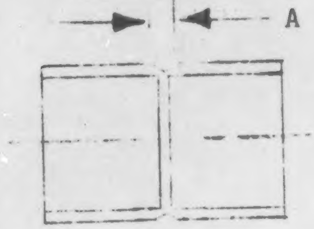
COUPLINGS

Staked Stop



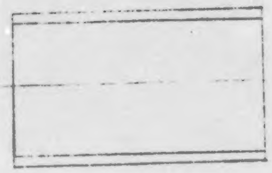
S x S

Rolled Stop



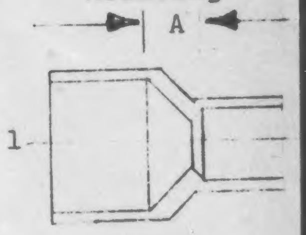
S x S

No Stop



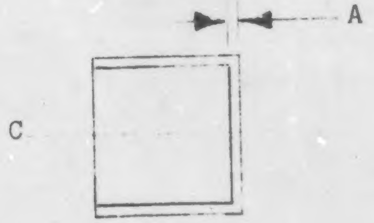
S x S

Reducing



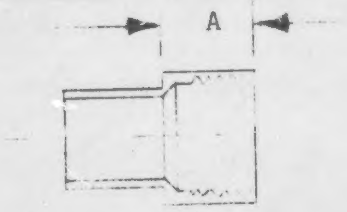
S x S

Caps

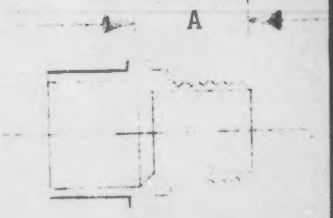


Solder

Adapters

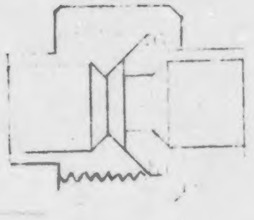


S x FPT

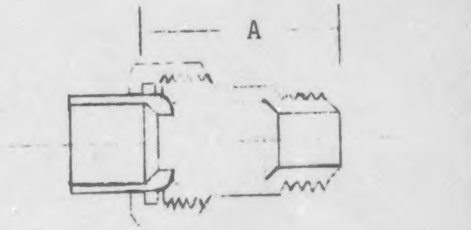


S x MPT

Union

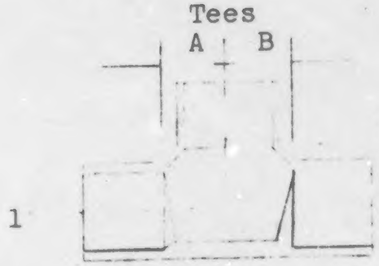


S x S



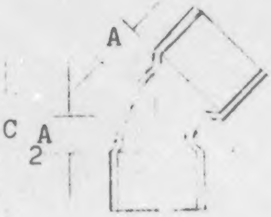
S x MPT

Tees



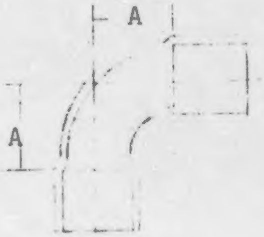
Tees
S x S x S

45°



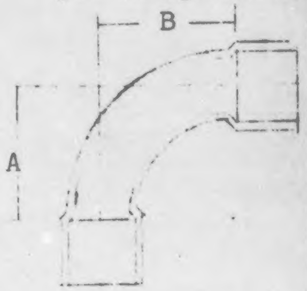
Ells
S x S

Ells
90°



S x S

90° Long Radius



S x S

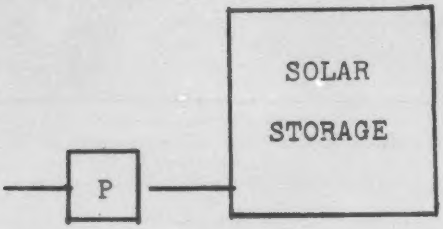
PIPE FITTINGS
UNIT II

ASSIGNMENT SHEET #1--LIST COPPER FITTINGS NECESSARY TO INSTALL COMPONENTS IN A SOLAR COLLECTOR LOOP

Directions: Fittings are read size, material, type.

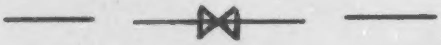
A. The pump inlet has a 1" FPT fitting that must connect to a 1" copper pipe.
List the fitting needed.

Answer ______________________________



B. A globe valve is installed in a 3/4" copper supply line with fittings that will permit removing the valve quickly without cutting.
List the fitting needed.

Answer ______________________________



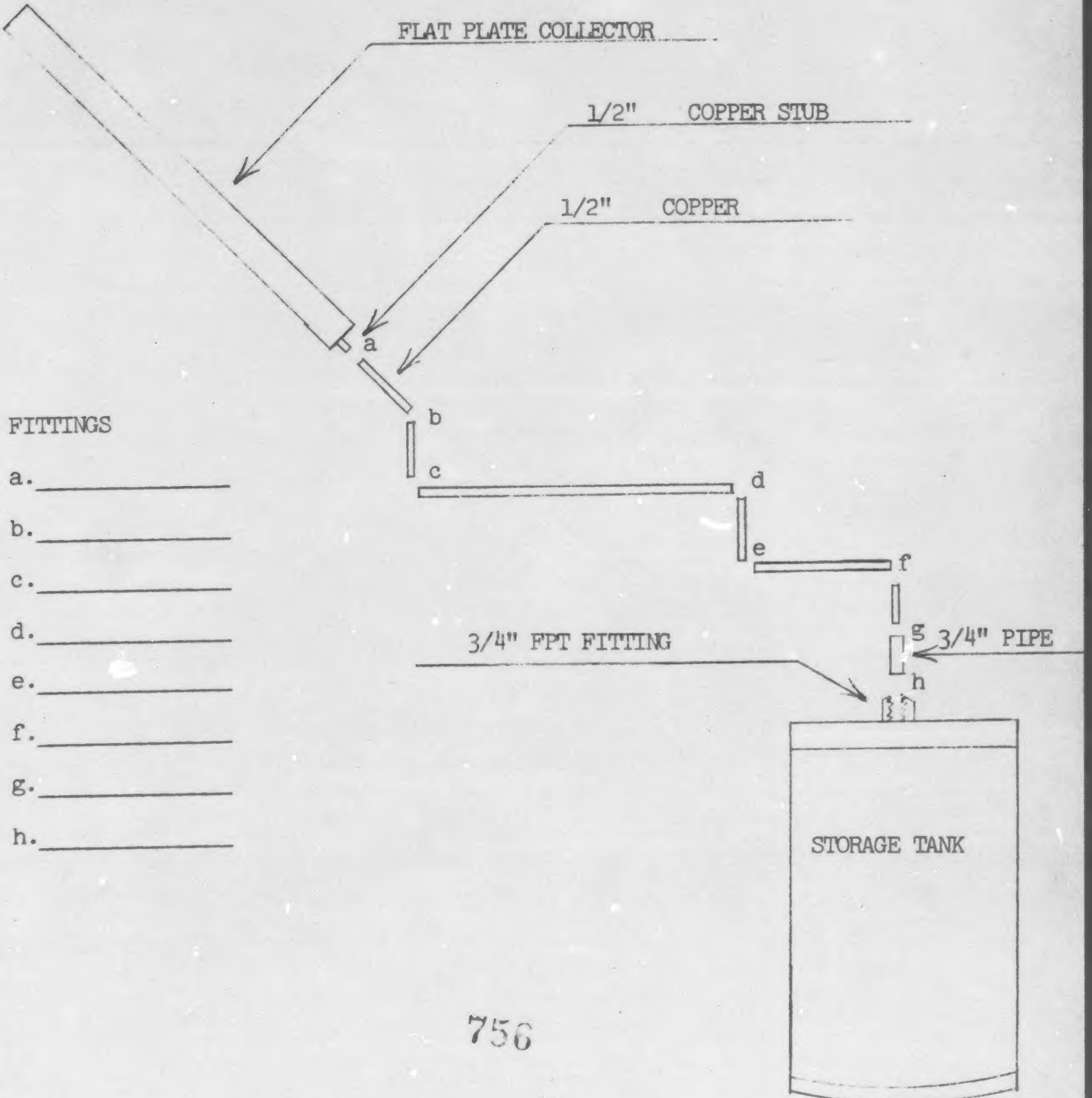
C. The inlet line to a flat plate collector is 3/4" copper that must connect to a 1/2" copper supply line.
List the fitting needed.

Answer ______________________________

PIPE FITTINGS
UNIT II

ASSIGNMENT SHEET #2--SELECT THE FITTINGS NECESSARY TO CONNECT THE SUPPLY LINE FOR A FLAT PLATE COLLECTOR LOOP

Make a list of the fittings necessary to connect the flat plate collector below to the solar water heater.



FITTINGS

a.________________

b.________________

c.________________

d.________________

e.________________

f.________________

g.________________

h.________________

PIPE FITTINGS
UNIT II

ASSIGNMENT SHEET #3--IDENTIFY FITTINGS FROM A SKETCH OF A PIPING SYSTEM

A. ____________________

B. ____________________

C. ____________________

D. ____________________

E. ____________________

F. ____________________

G. ____________________

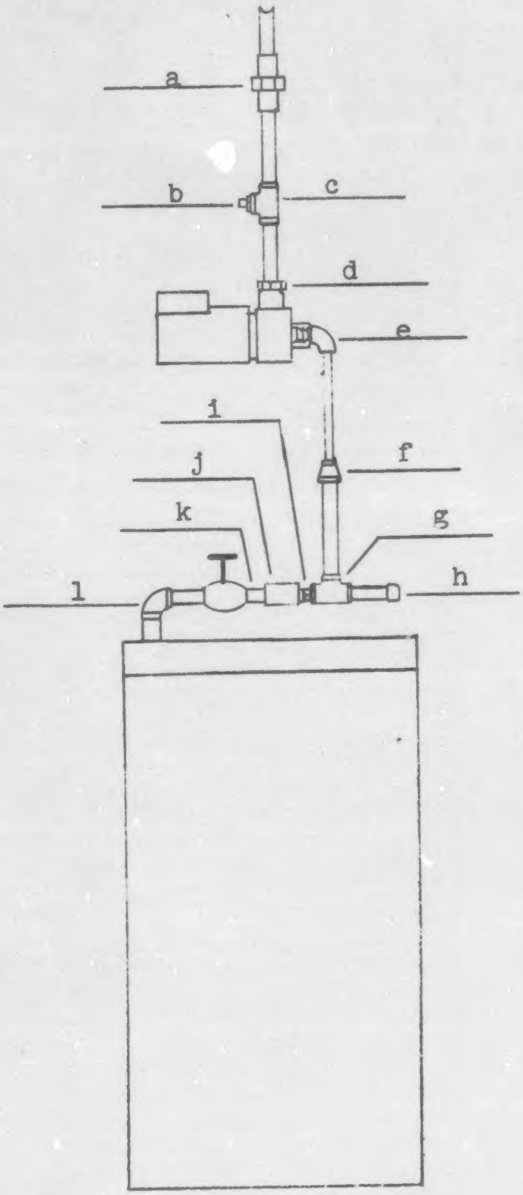
H. ____________________

I. ____________________

J. ____________________

K. ____________________

L. ____________________



PIPE FITTINGS
UNIT II

ANSWERS TO ASSIGNMENT SHEETS

1. A. 1" copper male adapter
   B. 3/4" copper union
   C. 3/4" x 1/2" copper reducer coupling
2. A. Coupling--solder x solder
   B. 45° ell--solder x solder
   C. 90° ell--solder x solder
   D. 90° ell--solder x solder
   E. 90° ell--solder x solder
   F. 90° ell--solder x solder
   G. Reducing coupling--solder x solder
   H. Male adapter--solder x M.P.T.
3. A. Union
   B. Plug
   C. Tee
   D. Bushing
   E. Street elbow
   F. Reducing coupling
   G. Tee
   H. Cap
   I. Close nipple
   J. Coupling
   K. Short nipple
   L. Elbow

S-69-F

PIPE FITTINGS
UNIT II

NAME________________________________

TEST

1. Match the terms on the right to the correct definitions or descriptions.

_____a. Those parts of the piping system which are used to join pipes and tubes

_____b. Type of fitting which joins pipes of different materials

_____c. Fitting used to reduce size

_____d. Fitting installed to allow parts of a system to be disconnected easily

_____e. A substance used on threaded joints to help make them tight, to lubricate them, and to fill in imperfections

_____f. Female pipe thread

_____g. Male pipe thread

_____h. Inflexible

_____i. Substitute for pipe compound

1. FPT
2. Pipe joint compound
3. Adapter
4. MPT
5. Union
6. Bushing
7. Fittings
8. Rigid
9. Thread tape

2. Match various materials used to make pipe fittings for solar systems with specific types.

a. Copper

1. ____________________________

2. ____________________________

b. Thermoplastic

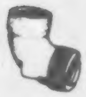
1. ____________________________

2. ____________________________

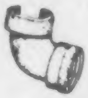
c. Steel Pipe

1. ____________________________

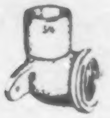
3. Match the name of fittings on the right to their proper application



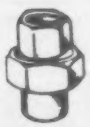
a. ____________



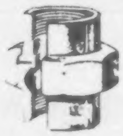
b. ____________



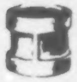
c. ____________



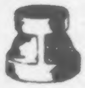
d. ____________



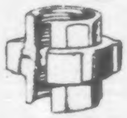
e. ____________



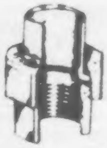
f. ____________



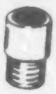
g. ____________



h. ____________



i. ____________

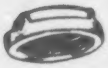


j. ____________

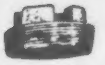
1. Drop-ear elbow (Copper to FIP)
2. Cast iron cap
3. Close nipple
4. Male street elbow (Copper)
5. Female adapter elbow (Copper)
6. Gasket type union (Galvanized iron)
7. Adapter coupling male to female
8. Reducing coupling
9. Straight union (Copper to copper)
10. Straight coupling (Galvanized iron)
11. Dielectric union (Copper)
12. Ground joint union (Galvanized iron)
13. Long nipple
14. Copper bushing
15. Cast iron plug (Solid)

16. Shoulder nipple

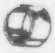
17. Cast iron bushing



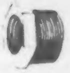
k.__________



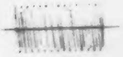
l.__________



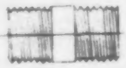
m.__________



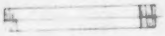
n.__________



o.__________



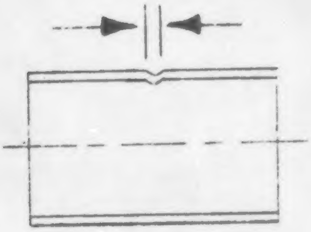
p.__________



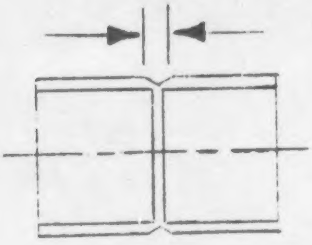
q.__________

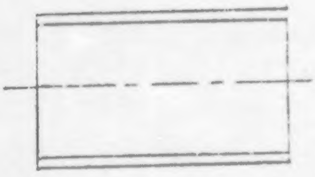
4. Identify assorted copper pipe fittings by their full name.

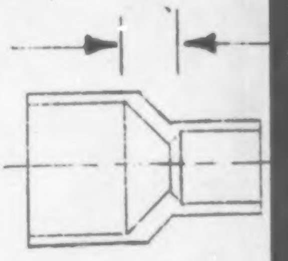
a. ______________________



c. ______________________

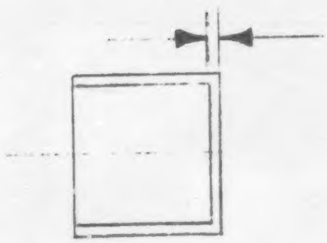


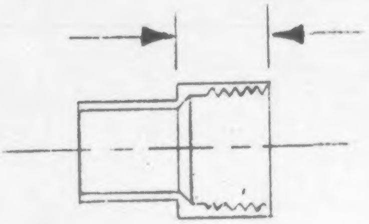


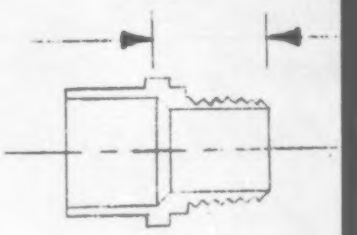


b. ______________________

d. ______________________



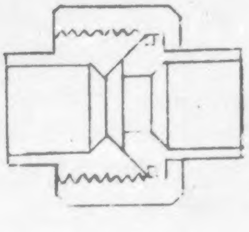


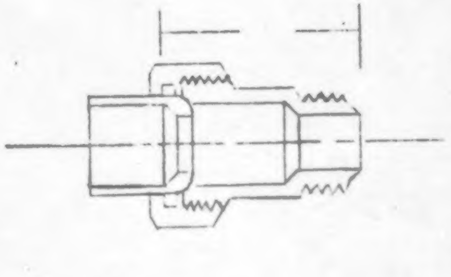


e. ______________________

f. ______________________

g. ______________________

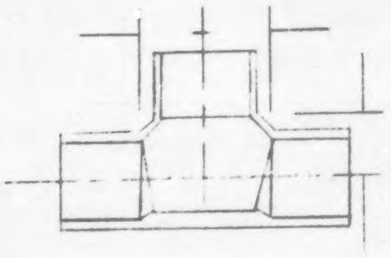


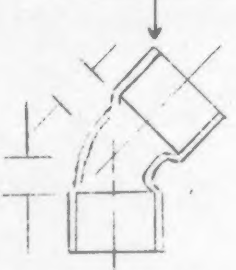


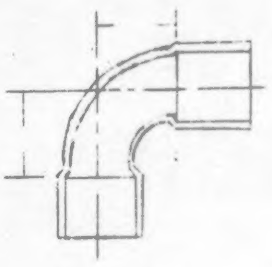
h. ______________________

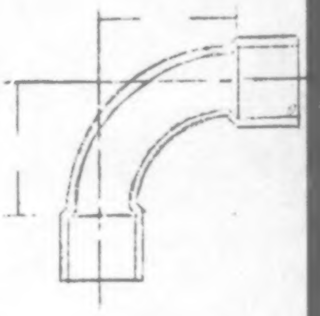
k. ______________________

i. ______________________









l. ______________________

j. ______________________

m. ______________________

5. Demonstrate the ability to:
    a. List copper fittings necessary to install components in a solar collector loop.
    b. Select pipe fittings necessary to connect the supply line for a flat plate collector loop.
    c. Identify fittings from a sketch of a piping system.

    (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

PIPE FITTINGS
UNIT II

ANSWERS TO TEST

1.
   a. 7
   b. 3
   c. 6
   d. 5
   e. 2
   f. 1
   g. 4
   h. 8
   i. 9

2.
   a. Copper
      1. Wrot
      2. Cast (brass)
   b. Thermoplastic
      1. P.V.C.
      2. C.P.V.C.
   c. Steel pipe
      1. Galvanized

3.
   a. 4
   b. 5
   c. 1
   d. 9
   e. 6
   f. 10
   g. 8
   h. 12
   i. 11
   j. 7
   k. 2
   l. 15
   m. 14
   n. 17
   o. 3
   p. 16
   q. 13

4.
   a. Coupling-staked stop
   b. Coupling-rolled stop
   c. Coupling-no stop
   d. Coupling-reducing
   e. Cap
   f. Adapter-Female
   g. Adapter-Male
   h. Union-solder x solder
   i. Union-solder MPT
   j. Tee-s x s x s
   k. Ell-45° s x s
   l. Ell-90° s x s (short)
   m. Ell-90° s x s (long radius)

5. Performance skills evaluated to the satisfaction of the instructor.

JOINING PIPES
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to select tools and equipment necessary to join pipe. The student should also demonstrate the ability to join steel, copper, and plastic pipe. This knowledge will be evidenced by correctly performing the procedures outlined on the job sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with joining pipe to the correct definitions or descriptions.
2. Select tools and equipment necessary to cut and thread steel pipe.
3. Select tools, equipment, and supplies necessary to join copper tubing by the sweat and flare joint methods.
4. Select tools and supplies necessary to join P.V.C. plastic pipe.
5. Demonstrate the ability to:
    a. Cut, ream, thread, and join a piece of 1" galvanized steel pipe to a 1" galvanized steel fitting.
    b. Cut, ream, and join copper tubing using the sweat method.
    c. Cut, ream, and join copper tubing using a flare joint.
    d. Cut, ream, and join copper tubing using a hammered flare joint.
    e. Cut, ream, and join P.V.C. pipe to a P.V.C. fitting.

JOINING PIPES
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet.
- B. Provide student with information and job sheets.
- C. Make transparencies.
- D. Discuss unit and specific objectives.
- E. Discuss information sheets.
- F. Demonstrate and discuss the procedures outlined in the job sheets.
- G. Review the proper use and care of the air acetylene torch.
- H. Give test.

II. Student:

- A. Read objective sheet.
- B. Study information sheet.
- C. Complete job sheets.
- D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Transparency masters
    1. TM 1--Tools and Equipment for Cutting and Threading Steel Pipe
    2. TM 2--Tools, Equipment, and Supplies to Join Copper Tubing by the Sweat Method
    3. TM 3--Tools to Join Copper Tubing by the Flare Method

4. TM 4--Tools and Supplies to Join P.V.C. Pipe

D. Job Sheets

1. Job Sheet #1--Cut, Ream, Thread, and Join a Piece of One Inch Galvanized Steel Pipe to a One Inch Fitting
2. Job Sheet #2--Cut, Ream, and Join Copper Tubing Using the Sweat Method
3. Job Sheet #3--Cut, Ream, and Join Copper Tubing Using a Flare Joint
4. Job Sheet #4--Cut, Ream, and Join Copper Tubing Using a Hammered Flare Joint
5. Job Sheet #5--Cut, Ream, and Join P.V.C. Pipe to a P.V.C. Fitting

E. Test

F. Answers to test

II. Unit References:

A. Blankenbaker, Keith E. Modern Plumbing. South Holland, Ill: Goodheart-Willcox, 1978.

B. Slater, Harry. Plumbing 1 and 2. Albany, New York: Delmar Publishing, 1958.

C. Bureau of Naval Personnel. Tools and Their Uses, Rate Training Manual. Washington, D.C.: U.S. Gov't Printing Office, 1971.

JOINING PIPES
UNIT III

INFORMATION SHEET

I. Terms and definitions or descriptions

- A. Sweating--Method of joining copper tubing using flux and solder applied with heat
- B. Threading--Cutting spiral grooves on the end of pipe to facilitate joining with a fitting or another pipe
- C. Cementing--Method of using a solvent to join P.V.C. pipe
- D. Reaming--Removing burrs from inside edge of pipe
- E. Pipe compound (dope)--Substance applied to pipe threads to help seal the joint
- F. Teflon tape--Tape used as a joint sealant in place of pipe

II. Tools and equipment necessary to cut and thread steel pipe (Transparency 1)

(NOTE: Steel pipe is also referred to as wrought iron pipe or just iron pipe.)

- A. Pipe vise
- B. Die head
- C. Reamer
- D. Oil can
- E. Die stock
- F. 4-wheel pipe cutter
- G. Cutter

III. Tools, supplies, and equipment necessary to join copper tubing

- A. Sweat joint method (Transparency 2)

        1. Copper tubing cleaning tool
        2. Tubing cutter
        3. Propane torch kit
        4. Abrasive sandcloth
        5. Copper fitting brush
        6. Striker
        7. Air-acetylene torch
        8. Soldering flux

           (NOTE: Soldering flux may be in liquid, paste, or powder form.)
        9. Acid (flux) brush
        10. Copper tubing brush

    B. Flare method (Transparency 3)

        1. Flare connection joint
        2. Swaging tool
        3. Copper tubing cutter
        4. Yoke and screw flaring tool
        5. Hammer type flaring tool
        6. Ball peen hammer

IV. Tools and supplies necessary to join P.V.C. plastic pipe.

    A. P.V.C. cement
    B. Knife
    C. P.V.C. cleaner
    D. Natural bristle or nylon brush
    E. Clean towels
    F. Handsaw

JOINING PIPES
UNIT III

INFORMATION SHEET

I. Terms and definitions or descriptions

   A. Sweating--Method of joining copper tubing using flux and solder applied with heat

   B. Threading--Cutting spiral grooves on the end of pipe to facilitate joining with a fitting or another pipe

   C. Cementing--Method of using a solvent to join P.V.C. pipe

   D. Reaming--Removing burrs from inside edge of pipe

   E. Pipe compound (dope)--Substance applied to pipe threads to help seal the joint

   F. Teflon tape--Tape used as a joint sealant in place of pipe

II. Tools and equipment necessary to cut and thread steel pipe (Transparency 1)

(NOTE: Steel pipe is also referred to as wrought iron pipe or just iron pipe.)

   A. Pipe vise

   B. Die head

   C. Reamer

   D. Oil can

   E. Die stock

   F. 4-wheel pipe cutter

   G. Cutter

III. Tools, supplies, and equipment necessary to join copper tubing

   A. Sweat joint method (Transparency 2)

1. Copper tubing cleaning tool
2. Tubing cutter
3. Propane torch kit
4. Abrasive sandcloth
5. Copper fitting brush
6. Striker
7. Air-acetylene torch
8. Soldering flux

   (NOTE: Soldering flux may be in liquid, paste, or powder form.)
9. Acid (flux) brush
10. Copper tubing brush

B. Flare method (Transparency 3)

1. Flare connection joint
2. Swaging tool
3. Copper tubing cutter
4. Yoke and screw flaring tool
5. Hammer type flaring tool
6. Ball peen hammer

IV. Tools and supplies necessary to join P.V.C. plastic pipe.

A. P.V.C. cement

B. Knife

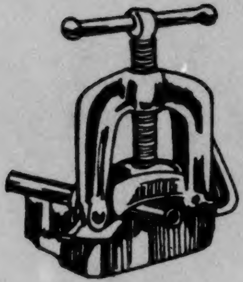
C. P.V.C. cleaner

D. Natural bristle or nylon brush

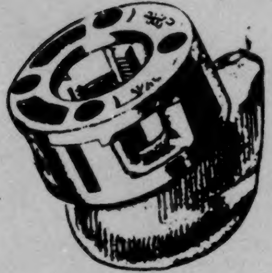
E. Clean towels

F. Handsaw

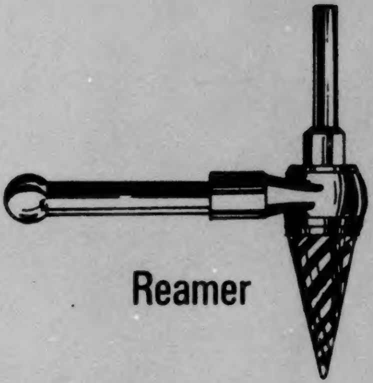
TOOLS AND EQUIPMENT FOR CUTTING AND THREADING STEEL PIPE



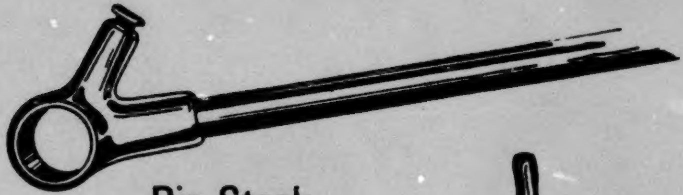
Pipe Vise



Die Head



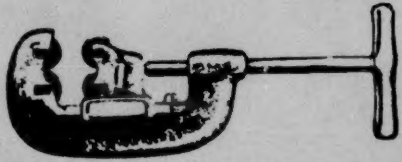
Reamer

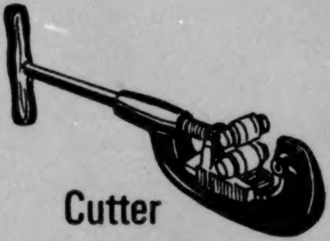


Die Stock

Oil Can

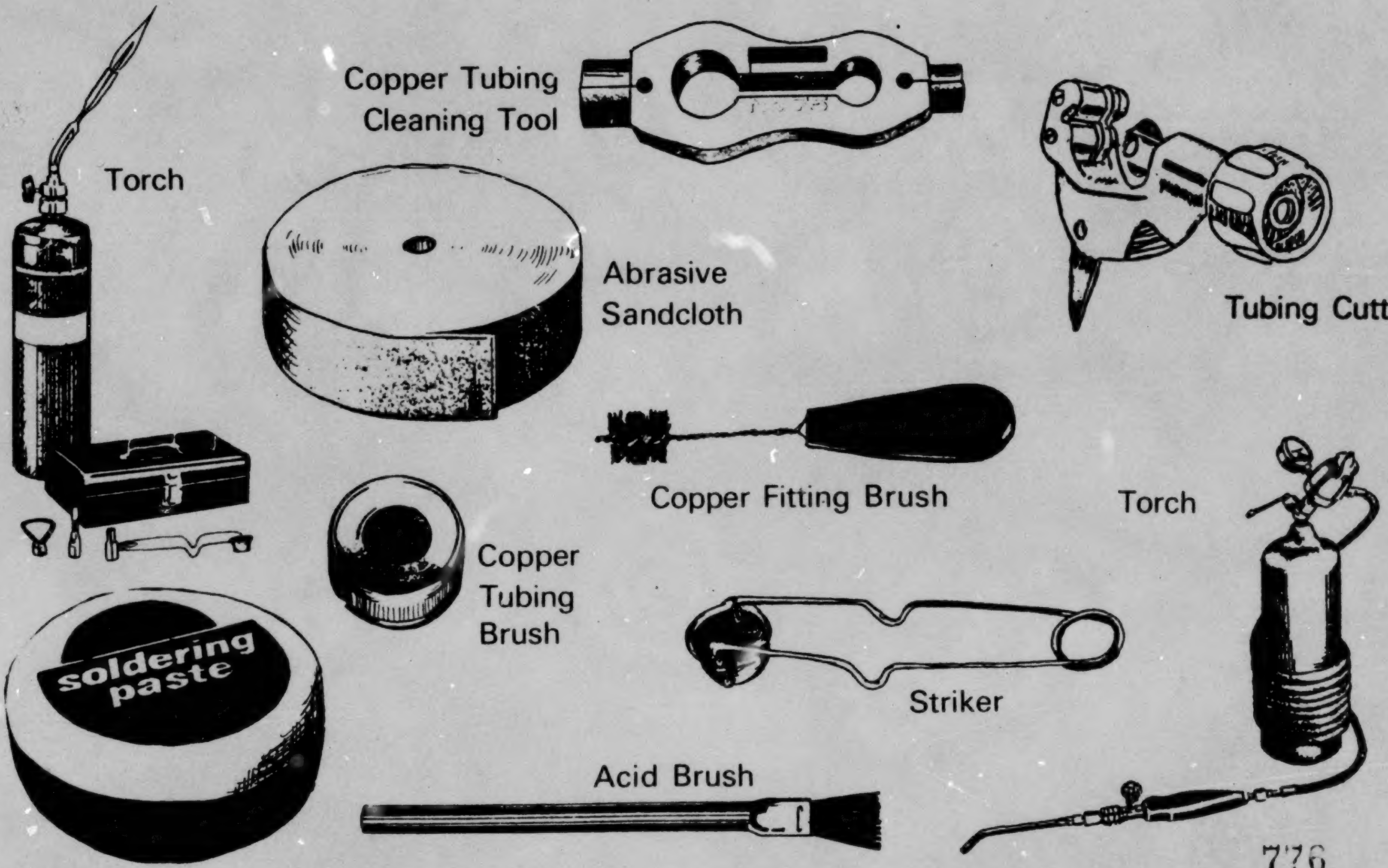
4–Wheel Pipe Cutter





Cutter

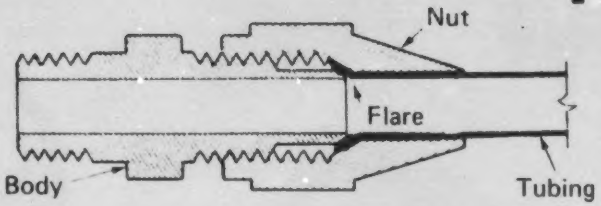
TOOLS, EQUIPMENT, AND SUPPLIES TO JOIN COPPER TUBING BY THE SWEAT METHOD



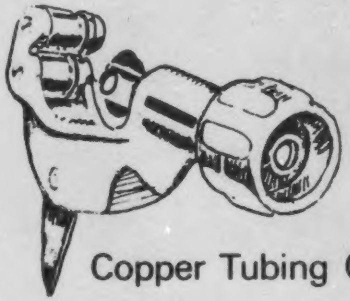
TM-2

S-85-F

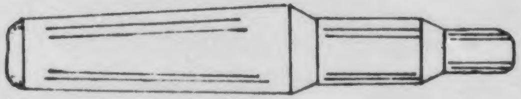
Tools to Join Copper Tubing by the Flare Method



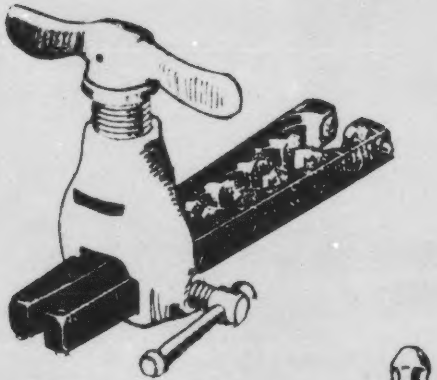
Flare Connection



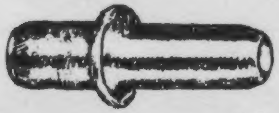
Copper Tubing Cutter



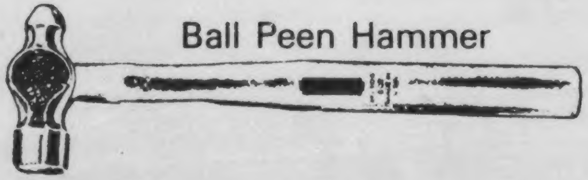
Swaging Tool



Yoke and Screw Flaring Tool



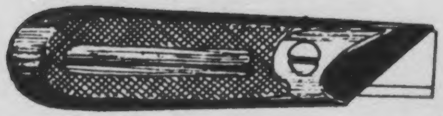
Hammer Type Flaring Tool



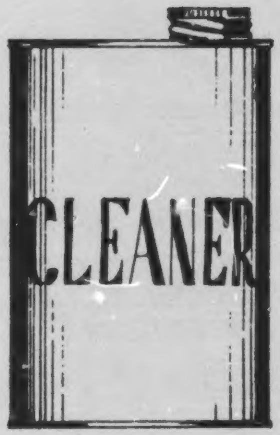
Ball Peen Hammer

TOOLS AND SUPPLIES TO JOIN P.V.C. PIPE

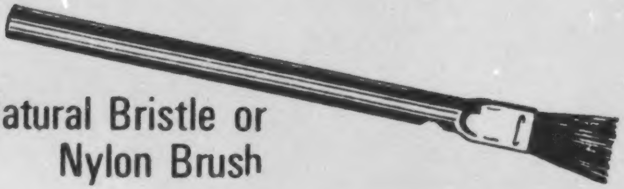
P.V.C. Cement



Knife

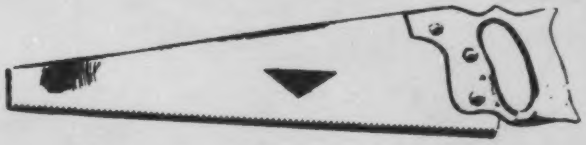


P.V.C. Cleaner



Natural Bristle or
Nylon Brush

Clean Towels



Handsaw

JOINING PIPES
UNIT III

JOB SHEET #1--CUT, REAM, THREAD, AND JOIN A PIECE OF ONE INCH GALVANIZED STEEL PIPE TO A ONE INCH FITTING

EVALUATION: Given access to tools, equipment and materials, cut, ream, thread, and join a piece of one inch galvanized steel pipe to a one inch fitting. The instructor will evaluate the use of correct methods, neatness, and general appearance.

I. Tools and materials

  A. Die

  B. Die stock

  C. Pipe vise

  D. Flat file

  E. Oil can (cutting oil)

  F. 1" steel pipe 12" long

  G. Pencil

  H. Shop towel

  I. Safety glasses

  J. Pipe cutter

  K. Reamer

  L. 1" galvanized union

II. Procedure

  A. Put on safety glasses and gather tools and equipment

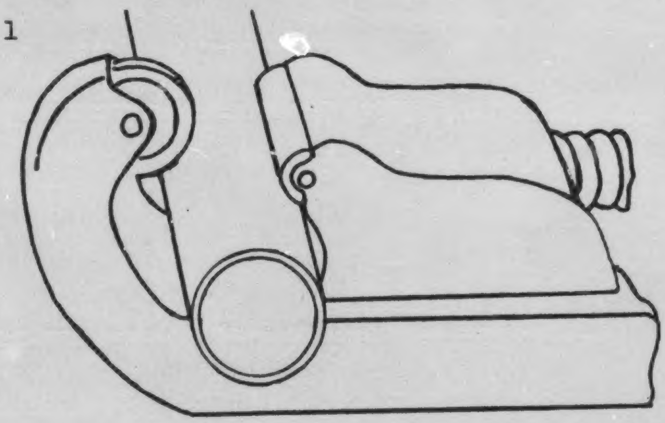
  B. Secure pipe in vise

  C. Mark place for cut with pencil

  D. Open pipe cutter until it will fit over pipe

E. Locate cutter wheel on the pencil mark (Figure 1)

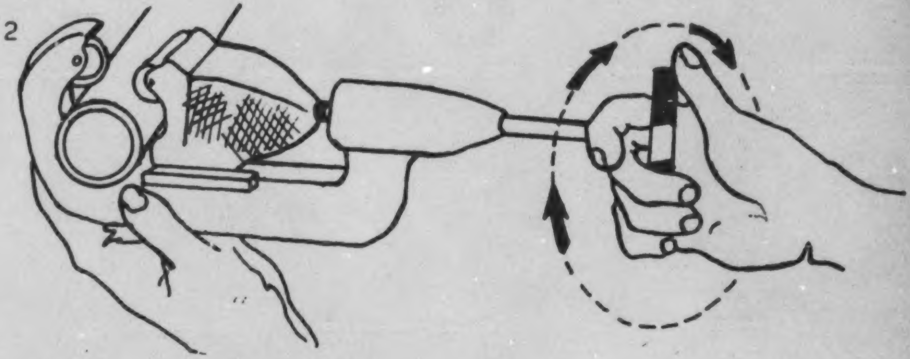
FIGURE 1



F. Snug cutter up to pipe by rotating screw handle (Figure 2)

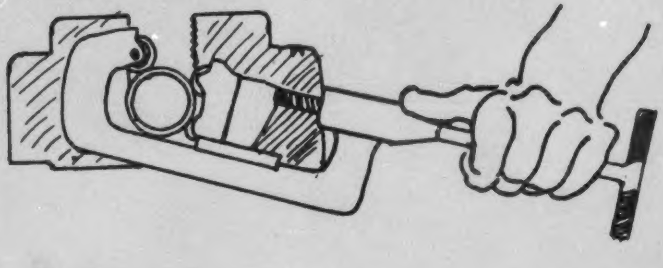
(NOTE: Don't overtighten as this can break cutter wheel.)

FIGURE 2



G. Rotate cutter counterclockwise to start groove (Figure 3)

FIGURE 3



H. Tighten cutter hand 1/4 of a turn for each full revolution around the pipe

(NOTE: Overtightening can cause cutters to break.)

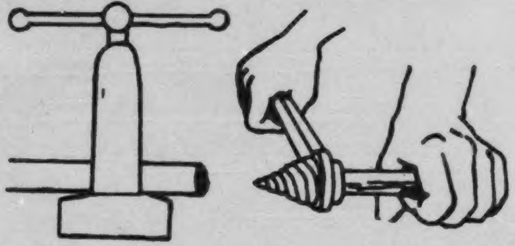
I. Continue process until pipe is cut

(CAUTION: When cutting short pieces of pipe be careful not to cut your arm while rotating the cutter around the pipe.)

J. Clean pipe and cutter with shop towel

K. Insert reamer tip in pipe (Figure 4)

FIGURE 4

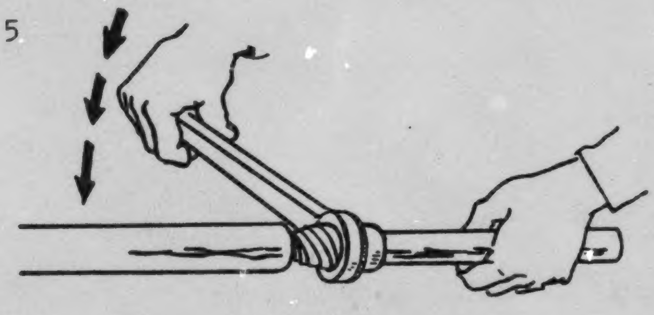


L. Apply light forward pressure to push reamer into pipe

M. Start rotating reamer (Figure 5)

(NOTE: Reamer should bite instantly if proper pressure is applied. Reamer can be damaged if rotated in the wrong direction.)

FIGURE 5



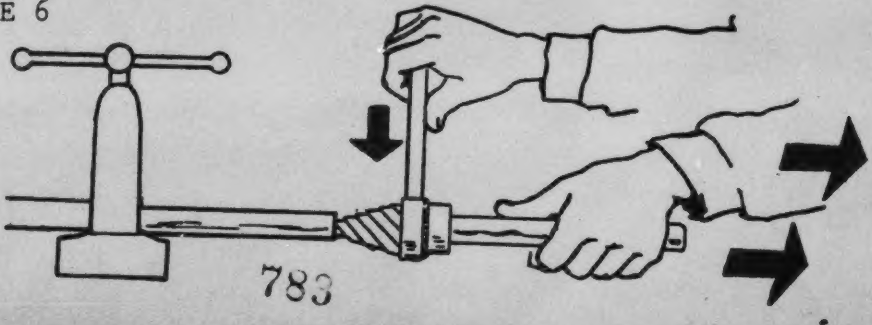
N. Rotate reamer until burrs are removed (Figure 5)

(NOTE: This is a developed skill; the reamer can be pulled out and your progress inspected.)

O. Pull reamer back while continuing to rotate (Figure 6)

(NOTE: This prevents the reamer from leaving a burr.)

FIGURE 6



P. Clean reamer with shop towel

Q. Lubricate end of pipe with cutting oil

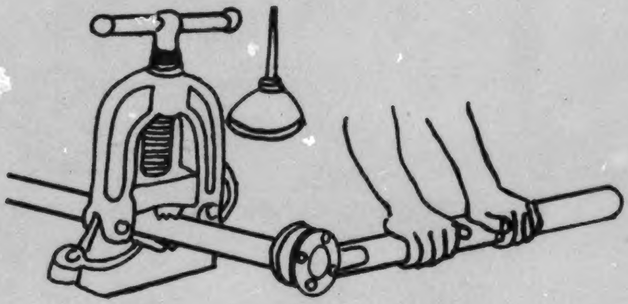
R. Place die in die stock and secure

S. Place die on pipe

T. Start die straight on the pipe

U. Press die on pipe evenly and turn the die (Figure 7)

FIGURE 7



V. Apply plenty of cutting oil while turning the die

(NOTE: Place a container under pipe vise to catch dripping oil.)

W. Continue this procedure until the desired amount of threads have been cut

X. Release die by turning ratchet lock 180°

Y. Remove die by turning counterclockwise

(NOTE: Hold onto the die stock firmly while removing it so as not to drop it when it comes to the end of the threads.)

Z. Clean threads with a brush

(CAUTION: Do not use compressed air for cleaning.)

AA. Wrap teflon tape around pipe threads beginning with the second thread.

(NOTE: Wrap in a clockwise direction to prevent unwinding of tape when tighting fitting

BB. Using a pipe wrench install the union

CC. Have instructor inspect work

DD. Clean up tools and put them away

EE. Clean up area.

JOINING PIPES
UNIT III

JOB SHEET #2--CUT, REAM, AND JOIN COPPER TUBING USING THE SWEAT METHOD

EVALUATION: Given access to tools, equipment and materials, cut, ream, and join copper tubing using the sweat method. Evaluation will include safety precautions used, correct methods and tools used, neatness, and general appearance of job.

I. Tools and materials

  A. Tubing cutter

  B. Reamer

  C. Sand cloth, emery cloth, steel wool

  D. Flux

  E. Torch

  F. Gas tank w/wrench

  G. Striker

  H. Wire solder

  I. Wiping cloth

  J. Tubing

  K. Fitting

  L. Colored safety glasses

II. Procedure

  A. Put on colored safety glasses

  B. Cut tubing to desired length

  C. Ream end of cut tubing

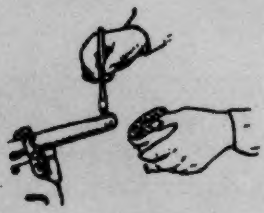
  D. Clean tubing end with sand cloth

  E. Clean fitting socket with sand cloth

F. Apply thin coat of flux to tubing end and fitting socket (Figure 1)

(NOTE: A small brush used to apply the flux helps to keep out dirt.)

FIGURE 1



G. Insert tubing end into fitting socket

(NOTE: Twist the tubing while inserting in order to spread the flux evenly.)

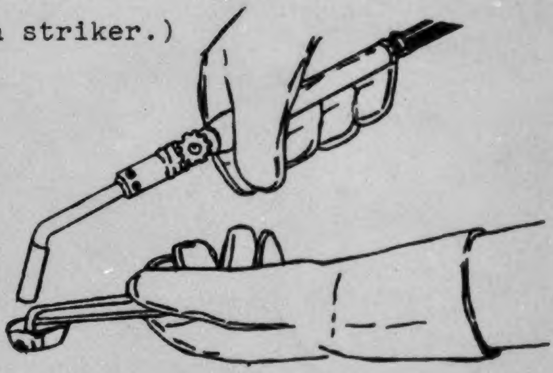
H. Clean away excess flux with cloth

I. Carefully secure tubing and fitting in vise

J. Light and adjust torch (Figure 2)

(NOTE: Always use a striker.)

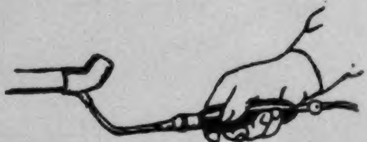
FIGURE 2



K. Apply heat to fitting (Figure 3

(NOTE: The inner blue cone of the flame should be about 1/8" away from the fitting.)

FIGURE 3



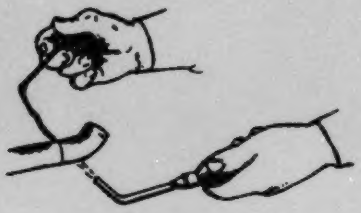
Used with permission of Goodheart-Willcox Company, South Holland, Illinios, from Modern Plumbing by E. Keith Blankenbaker, 1973.

L. Move the torch flame around the entire joint

M. Apply solder (Figure 4)

(NOTE: Amount of solder is determined by size of tubing, i.e., 1/2" tubing will need approximately 1/2" wire solder, and 3/4" tubing 3/4" wire solder.)

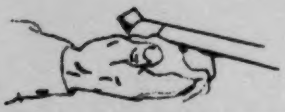
FIGURE 4



N. Discontinue heat and solder application when solder flows from joint

O. If necessary, wipe excess solder off with cloth (Figure 5)

FIGURE 5



O. Turn off torch

P. Allow solder to cool

(NOTE: Do not apply water to cool the fitting.)

Q. Clean up area and put tools away

JOINING PIPES
UNIT III

JOB SHEET #3--CUT, REAM, AND JOIN COPPER TUBING USING A FLARE JOINT

EVALUATION: Given access to tools, equipment, and materials, cut, ream, and join copper tubing using a flare joint. Evaluation will include safety precautions used, correct methods and use of tools, and general appearance of the job.

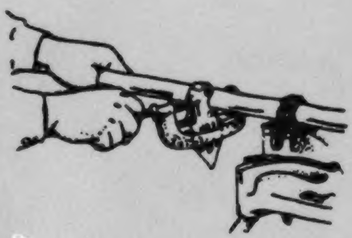
I. Tools and materials

- A. Tubing cutter
- B. Reamer
- C. Flaring tool and block
- D. Tubing
- E. Fitting
- F. Adjustable wrench
- G. Open-end or flare-nut wrench

II. Procedure

- A. Measure and cut a desired length of tubing
  1. Place cutter on tubing; do not overtighten (Figure 1)

FIGURE 1



  2. Turn a few revolutions and then tighten a little more
  3. Continue to tighten a little at a time while turning cutter

  (NOTE: Cutter should not be so tight that it bends the end of the tubing.)

B. Slip flare nut over end of tubing

C. Ream the end of the tubing

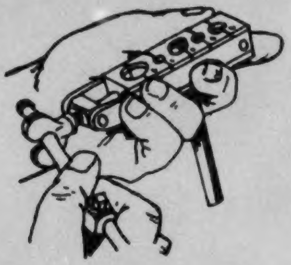
  1. Do not over-ream; just remove the burr

  2. Point end of tubing slightly downward while reaming to allow chip to fall out

D. Place tubing in falring block

E. Extend end of tubing above the block face about 1/3 the depth of the block chamfer (Figure 2)

FIGURE 2



F. Secure tubing in flaring block

G. Place flaring tool on block

(NOTE: Flaring tool must be kept oiled and clean.)

H. Tighten cone into tubing a few turns and then back it out

I. Continue the tightening and loosening process until the flare is made

(NOTE: This process tends to make a smooth, polished flare and will lessen the chances of work hardening the tubing.)

J. Do not overtighten the flaring tool

(NOTE: This will cause the tubing to wash-out and possibly cause the flare to split.)

K. Remove flaring tool from block

L. Remove tubing from flaring block

M. Check fit of flare to seat of flare nut

N. Secure flare nut tightly to flare fitting

O. Duplicate process on other end of flare fitting

P. Clean up area and put tools away

JOINING PIPES
UNIT III

JOB SHEET #4--CUT, REAM, AND JOIN COPPER TUBING USING A HAMMERED FLARE JOINT

EVALUATION: Given access to tools, equipment, and materials, cut, ream, and join copper tubing using a hammered flare joint. Evaluation will include safety precautions used, correct methods and use of tools, and general appearance of the job.

I. Tools and materials

- A. Tubing cutter
- B. Reamer
- C. Flaring tool
- D. Small ball peen hammer
- E. Fitting
- F. Tubing
- G. Adjustable wrench
- H. Open-end or flare nut wrench

II. Procedure

- A. Measure and cut a desired length of tubing
    1. Place cutter on tubing, do not overtighten
    2. Turn a few revolutions and then tighten a little more
    3. Continue to tighten a little at a time while turning cutter

       (NOTE: Cutter should not be so tight that it bends the end of the tubing.)
- B. Slip flare nut over end of tubing
- C. Ream the end of the tubing
    1. Do not over-ream; just remove the burr

2. Point end of tubing slightly downward while reaming to allow chips to fall out

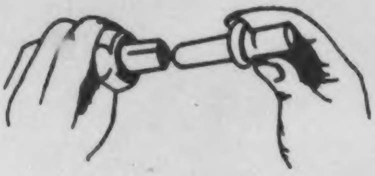
D. Carefully clean inside end of tubing

E. Carefully clean flaring tool

(NOTE: Flaring tool should be cleaned and oiled before and after use.)

F. Place end of flaring tool in end of pipe (Figure 1)

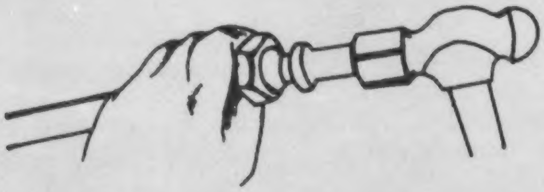
FIGURE 1



G. Holding tubing and flaring tool in one hand, drive flaring tool into tubing with hammer (Figure 2)

(NOTE: Tubing and flaring tool must be held straight.)

FIGURE 2



H. Drive flaring tool into tubing until desired flare is formed.

(NOTE: This may require checking flare on fitting.)

I. Remove flaring tool from tubing

(NOTE: This may require turning flaring tool in order to loosen it.)

J. Check fit of flare to seat of flare nut

K. Secure flare nut tightly to flare fitting

L. Duplicate process on other end of flare fitting

M. Clean up area and put away tools

JOINING PIPES
UNIT III

JOB SHEET #5--CUT, REAM, AND JOIN P.V.C. PIPE TO A P.V.C. FITTING

EVALUATION: Given access to tools, equipment and materials, cut, ream, and join P.V.C. pipe to a P.V.C. fitting. Evaluation will include accuracy of cut pipe, correct methods and tools used, neatness of job, and use of safety precautions.

I. Tools and materials

  A. Pipe cutter or handsaw with mitre box

  B. Reamer

  C. Cleaning solvent with brush or abrasive paper

  D. Solvent cement with brush

  E. Pipe

  F. Fitting

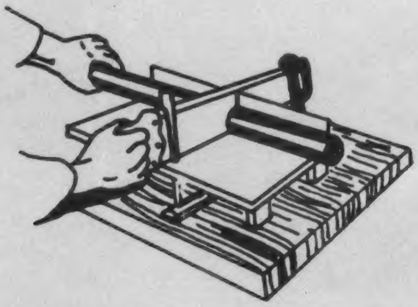
  G. Wiping cloth

II. Procedure

  A. Measure and cut pipe to desired length

  (NOTE: A mitre box and mitre saw insures a square cut. See Figure 1.)

  FIGURE 1



  B. Ream pipe

  (CAUTION: Since most P.V.C. reaming is done with a pocket knife or other types of knives, care must be exhibited in this operation.)

C. Apply solvent cleaner to pipe end and fitting socket

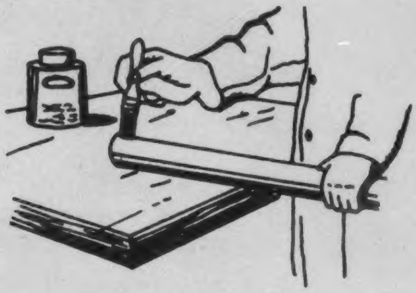
(NOTE: Abrasive paper such as sand cloth or emery cloth may be used.)

D. Wipe solvent cleaner from the pipe end and fitting socket

(NOTE: This cleans the pipe and removes the gloss for better bonding.)

E. Apply a light, even coat of solvent cement to the pipe end and fitting socket (Figure 2)

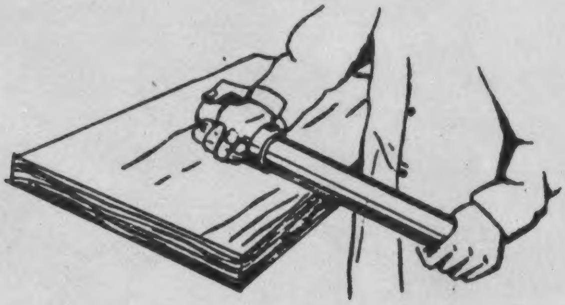
FIGURE 2



F. Insert pipe all the way into the fitting socket while giving it a quarter turn (Figure 3)

(NOTE: This operation must be done quickly as the cement sets-up in a few seconds.)

FIGURE 3



G. Allow sufficient time for drying of cement before testing joints.

(NOTE: Drying time will vary according to ambient temperature.)

H. Clean up area and put tools away.

JOINING PIPES
UNIT III

NAME_______________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Method of using a solvent to join P.V.C. pipe

_____b. Method of joining copper tubing using flux and solder applied with heat

_____c. Removing burrs from inside edge of pipe

_____d. Cutting spiral grooves on the end of pipe to facilitate joining with a fitting or another pipe

_____e. Substance applied to pipe threads to help seal the joint

1. Threading
2. Cementing
3. Reaming
4. Pipe compound (dope)
5. Sweating

2. Select tools and equipment necessary to cut and thread steel pipe by placing an "X" in the appropriate blanks.

_____a. Cutter

_____b. Reamer

_____c. Open end wrench

_____d. Oil can

_____e. Aviation wire snips

_____f. Pipe vise

_____g. Stock-and-die set

_____h. Screwdriver

_____i. Pipe dope

_____j. Paint

_____k. Pipe wrench

_____l. Pipe

_____m. Fitting

3. Select tools, equipment, and supplies necessary to join copper tubing by the sweat and flare joint methods by placing an "X" in the appropriate blank.

a. Sweat joint method

_____1. Tubing cutter

_____2. Fitting

_____3. Gas tank with wrench

_____4. Open-end wrench

_____5. Flux with brush

_____6. Sand cloth

_____7. Solvent cement

_____8. Wire solder

_____9. Tubing

_____10. Handsaw

_____11. Torch

_____12. Striker

b. Flare method

_____1. Tubing cutter

_____2. Torch

_____3. Flaring tool and block

_____4. Cleaning solvent

_____5. Reamer

_____6. Flare-nut wrench

_____7. Adjustable wrench

4. Select tools and supplies necessary to join P.V.C. plastic pipe by placing an "X" in the appropriate blanks.

   a. P.V.C. pipe

      _____1. Handsaw with mitre box

      _____2. Reamer

      _____3. Clamp

      _____4. Screwdriver

      _____5. Solvent cement with brush

      _____6. Pipe

      _____7. Cleaning solvent with brush

5. Demonstrate the ability to:

   a. Cut, ream, thread, and join a piece of 1" galvanized steel pipe to a 1" galvanized steel fitting.

   b. Cut, ream, and join copper tubing using the sweat method.

   c. Cut, ream, and join copper tubing using a flare joint.

   d. Cut, ream, and join copper tubing using a hammered flare joint.

   e. Cut, ream, and join P.V.C. pipe to a P.V.C. fitting.

   (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

JOINING PIPES
UNIT III

ANSWERS TO TEST

1. a. 2
   b. 5
   c. 3
   d. 1
   e. 4

2. a, b, d, f, g, i, k, l, m

3. a. 1, 2, 3, 5, 6, 8, 9, 11, 12
   b. 1, 3, 5, 6, 7

4. a. 1, 2, 5, 6, 7,

5. Performance skills evaluated to the satisfaction of the instructor.

BLUEPRINT READING
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with blueprint reading to the correct definitions and identify the alphabet of lines and drawing symbols. The student should also be able to measure scaled lines. This knowledge will be evidenced by correctly performing the procedures outlined on the assignment sheets and by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with blueprint reading to their correct definitions.
2. Identify five types of architectural drawings.
3. Identify five types of lines included in the alphabet of lines.
4. Match the name of plan drawing symbols to a picture of the symbol.
5. Identify plumbing, appliance, and structural symbols.
6. Match the name of six piping symbols for plumbing.
7. List three rules for reading the architect's scale.
8. Demonstrate the ability to:
    A. Read the architect's scale at 12" = 1'-0"
    B. Read the architect's scale at half scale (6" = 1'- 0")

BLUEPRINT READING
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide students with objective sheet.
- B. Provide students with information and assignment sheets.
- C. Make transparencies.
- D. Discuss unit and specific objectives.
- E. Discuss information and assignment sheets.
- F. Invite an inspector and/or architect to speak to the class.
- G. Give test.

II. Student:

- A. Read objective sheet.
- B. Study information sheet.
- C. Complete assignment sheets.
- D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Transparency masters
    1. TM 1--Plot Plan
    2. TM 2--Foundation Plan
    3. TM 3--Floor Plan
    4. TM 4--Elevations

5. TM 5--Details
6. TM 6--Alphabet of Lines
7. TM 7--Alphabet of Lines (Continued)
8. TM 8--Alphabet of Lines (Continued)
9. TM 9--Floor Plan Symbols
10. TM 10-a--Plumbing Symbols
11. TM 10-b--Appliance and Structural Symbols
12. TM 10-c--Structural Symbols (Continued)
13. TM 11--The Architect's Scale

D. Assignment Sheets

1. Assignment Sheet #1--Read the Architect's Scale at Full Scale or (12" = 1'0")
2. Assignment Sheet #2--Read the Architect's Scale at Half Scale or (6" = 1'0")

E. Answers to assignment sheets

F. Test

G. Answers to test

II. References:

A. D'Arcangelo Bartholomew, Et. Al., Blueprint Reading For Plumbers. New York: Delmar, 1973.

B. Dalzell, James R. Blueprint Reading For Home Builders. New York: McGraw-Hill, 1955.

C. French, Thomas E. and Charles J. Vierch. Engineering Drawing. New York: McGraw-Hill, 1966.

D. Hartman, William J. Basic Drafting. Stillwater, Oklahoma: State Department of Vocational and Technical Education, 1972.

E. Helper, Donald E. and Paul I. Wallach. Architectural Drafting and Design. New York: McGraw-Hill, 1971.

BLUEPRINT READING
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Alphabet of lines--Set of conventional symbols covering all the lines needed to depict an object as to size and shape

B. Architect's scale--A rule divided into proportional feet and inches; a fraction of an inch is proportionally equal to one foot

Examples: 1/8, 1/4, 3/8, 1/2, 3/4, 1 1/2, and 3 inches to the foot

C. Architectural drawings--Step by step directions which are shown in picture form

(NOTE: They are sometimes called construction drawings.)

D. Blueprint--A copy of the original detailed drawing

E. Building code--Collection of laws listed in booklet form that apply to a given community, state or nation

F. Detail view--A drawing that gives complete detailed information for the construction of a single part

G. Dimensions--The arrangement of lines and symbols to indicate the actual size for constructing the object that is represented

H. Elevation view--Drawings representing the front, sides or rear face of a building and usually made as though the observer were looking straight at it

I. Plan view--Horizontal cut through a building showing the foundation, rooms, partitions, windows, doors, and stairs

J. Scale drawing--A drawing made to size either proportionally larger or smaller than the actual size of the object represented

K. Section view--A drawing of an object that has been cut to show internal construction

L. Specifications--A detailed set of written instructions which explains the drawing and becomes part of the contract

M. Symbol--An arbitrary sign that has been standardized and is used to represent an object, quality, or method

N. Working drawing--A technical drawing which includes all dimensions and procedures to guide workers in the construction of a building

O. Roof Pitch--Angle of roof designed to drain rain water and also adds to beauty of the building

II. Types of architectural drawings (Transparencies 1, 2, 3, 4, and 5)

A. Plot plan--Characteristics include:

(NOTE: The entrance to the building should be located at the bottom of the page.)

1. The location of the building on the lot

   (NOTE: The plot plan sometimes shows legal descriptions of the building.)

2. Finished grade contours

3. Property lines

4. Available utilities

5. Location of existing trees

B. Foundation plan--Characteristics include:

(NOTE: The entrance to the building should be located at the bottom of the page.)

1. The location of footings, stemwalls, and piers

2. Openings and clearance for crawl space under a conventional wood floor

3. Entrance for underground utilities and services

C. Floor plan--Characteristics include:

(NOTE: The entrance to the building should be located at the bottom of the page on the plan.)

INFORMATION SHEET

1. Outside walls including the location and dimensions of all exterior openings
2. The type of construction through the use of symbols
3. The location of interior walls and partitions
4. The way a door is to swing
5. Stairways
6. The location of cabinets and built-ins and plumbing fixtures

D. Elevation

1. Characteristics
    a. Grade line
    b. Floor heights
    c. Head and sill heights of windows in each story
    d. Roof line and pitch
2. Typical elevations
    a. Front
    b. Left
    c. Right
    d. Rear
    e. Sectional (optional)

E. Details--Characteristics include:

(NOTE: These drawings are primarily used to depict details of construction that are too small or not clearly shown on the plan or elevation drawings. They may be full size or to a larger scale than the plan elevation, or a sectional view.)

1. Fireplace
2. Stairs

(NOTE: Sections are used freely on these drawings.)

INFORMATION SHEET

III. Alphabet of lines (Transparencies 6, 7, and 8)

A. Object lines (______________)--Show the main outline of the building including exterior walls, interior partitions, porches, patios, driveways, and interior walls; these lines should be outstanding lines on a drawing

B. Dimension Lines (←————————→)--Thin unbroken lines which building dimensions are placed upon

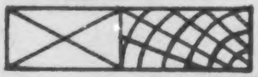
C. Extension lines (______________)--Extend, but do not touch, the object lines and permit dimension lines to be drawn between them

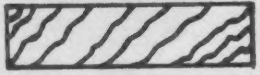
D. Hidden lines (_ _ _ _ _ _ _ _ _)--Short dashes used to show lines that are not visible from that view

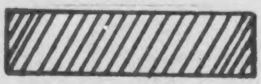
E. Center lines (____ _ _____ _ __)--A series of short and long dashes used to designate the center of doors, windows, and circles and to provide a reference point for dimensioning

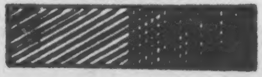
IV. Symbols

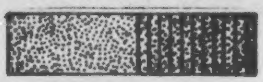
A. Floor plan (Transparencies 9

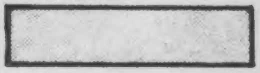
1. Wood (rough) 

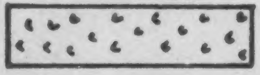
2. Wood (finished) 

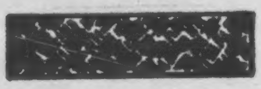
3. Brick 

4. Firebrick 

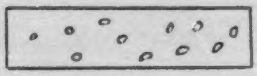
5. Concrete  ← Conc Block

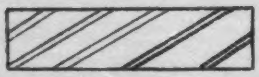
6. Sand, plaster, cement, gypsum board 

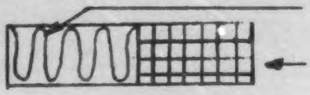
7. Cinders 

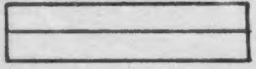
8. Earth 

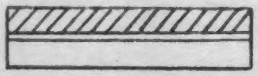
INFORMATION SHEET

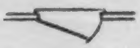
9. Gravel  With Sand

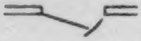
10. Structural steel or iron 

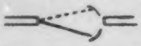
11. Insulation  Loose Solid

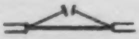
12. Flashing, termite barrier, waterproofing 

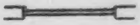
13. Brick veneer 

14. Outside door 

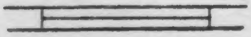
15. Inside door 

16. Double-acting door 

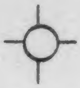
17. Casement window 

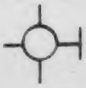
18. Double-hung window 

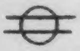
19. Floor drain

20. Glass 

B. Electrical

1. Ceiling outlet 

2. Wall bracket outlet 

3. Duplex outlet 

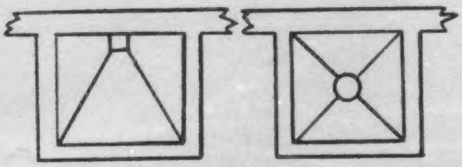
INFORMATION SHEET

4. Switch (single pole) S1

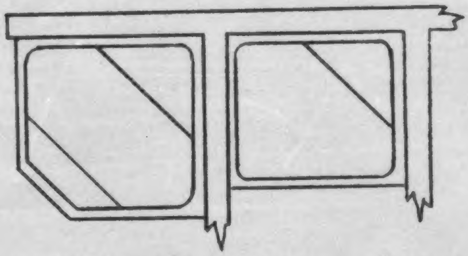
5. Switch (3 way) S3

V. Plumbing, appliance, and structural symbols

A. Plumbing--(Transparency 10-a)

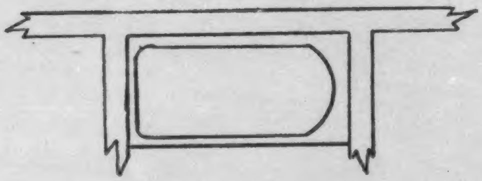


1. SHOWERS

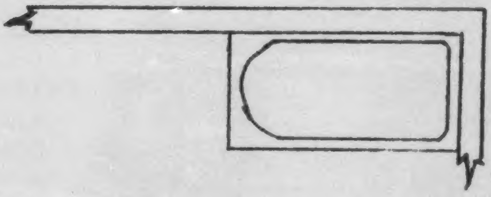


2. SQUARE CORNER BATHTUB

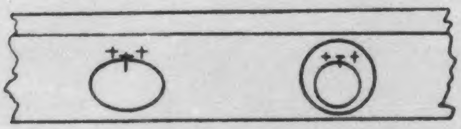
3. BUILT-IN SQUARE BATHTUB



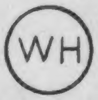
4. BUILT-IN BATHTUB (RECESSED)



5. Corner bathtub



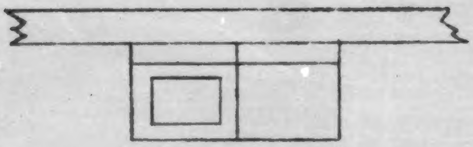
6. BUILT-IN LAVATORIES



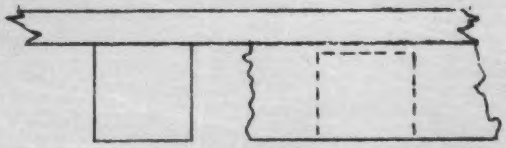
B. Appliances--
(Transparency 10-b)

1. WATER HEATER (DESIGNATE CAPACITY AND FUEL)

INFORMATION SHEET



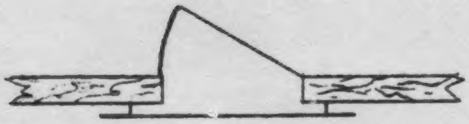
2. WASHER AND DRYER



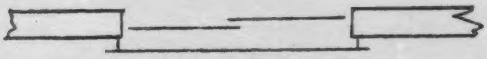
3. FREESTANDING AND BUILT-IN DISHWASHERS

C. Structural symbols--(Transparency 10-c)

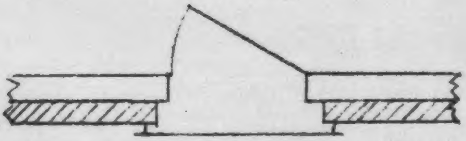
1. PLAN VIEW OF EXTERIOR DOOR IN WOOD FRAME WALL



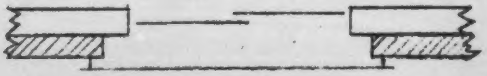
2. PLAN VIEW OF EXTERIOR SLIDING DOOR IN WOOD FRAME WALL



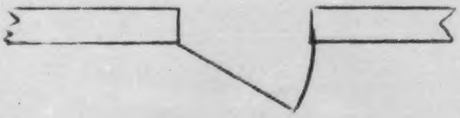
3. PLAN VIEW OF EXTERIOR DOOR IN MASONRY VENEER WALL



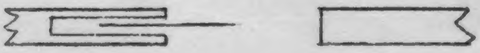
4. PLAN VIEW OF EXTERIOR SLIDING DOOR IN MASONRY VENEER WALL



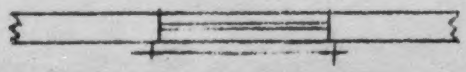
5. PLAN VIEW OF INTERIOR HINGED DOOR



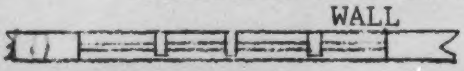
6. PLAN VIEW OF INTERIOR POCKET DOOR



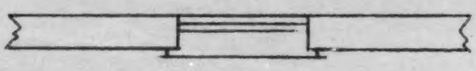
7. SINGLE WINDOW IN FRAME WALL



8. MULTIPLE WINDOWS IN FRAME WALL



INFORMATION SHEET



9. PLAN VIEW OF DOUBLE HUNG WINDOW
IN FRAME WALL

VI. Piping Symbols For Plumbing

A.	— — — — —	Vent
B.	______sd______	Storm Drain
C.	— - ——— - —	Cold Water
D.	— - - ——— -	Hot Water
E.	_____g__g_____	Gas
F.	$\boxed{\text{FD}}$	Floor Drain

VII. The architect's scale (Transparencies 11)

A. Rules for reading a scale

1. Select proper scale ratio
2. Scale should lay flat on the surface being measured
3. Double check all measurements
4. Practice measuring from the center of one line to the center of the next line
5. Do not use a scale where dimensions are available

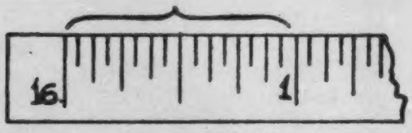
INFORMATION SHEET

B. Interpreting graduations on the architect's scale

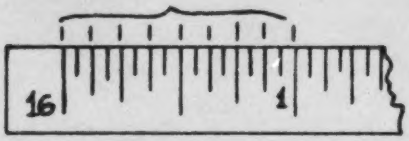
(NOTE: Some scales read from right to left and vice versa.)

1. The sixteenth scale

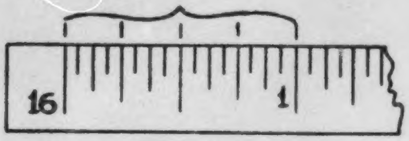
   a. 16-16ths make one inch



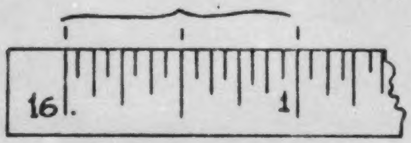
   b. 8-8ths make one inch; 2-1/16" make 1/8"



   c. 4-4ths make one inch; 4-1/16" make 1/4"



   d. 2-1/2"s make one inch; 8-1/16"s make one inch



   e. Dimensions are read in this order

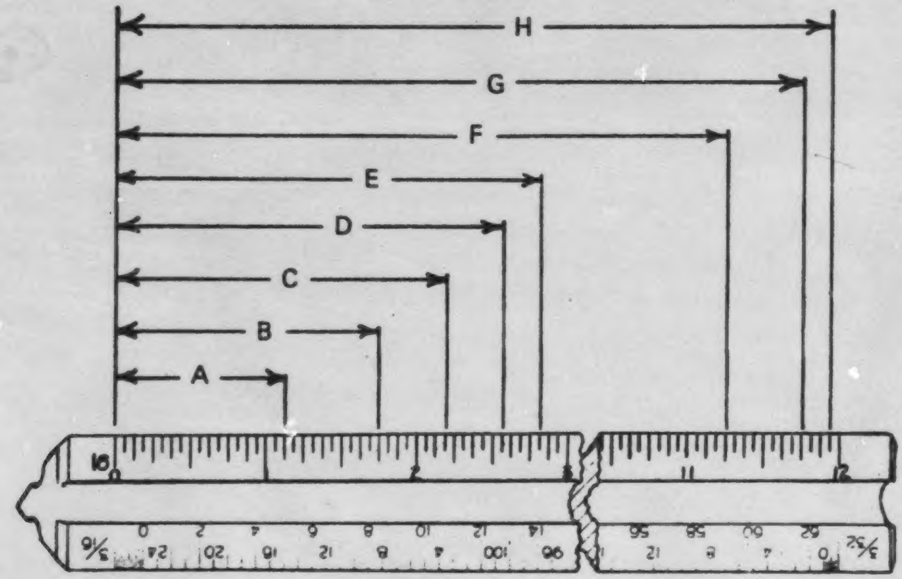
      1) Feet marked thus (')

      2) Inches marked thus (")

      3) Fractions of an inch

INFORMATION SHEET

f. Practice reading the following dimensions in inches and 1/16" (full scale)



1) A = 1" + 2/16" = 1 2/16" or 1 1/8"

2) B = 1" + 12/16" = 1 12/16" or 1 3/4"

3) C = 2" + 3/16" = 2 3/16"

4) D = 2" + 9/16" = 2 9/16"

5) E = 2" + 13/16" = 2 13/16"

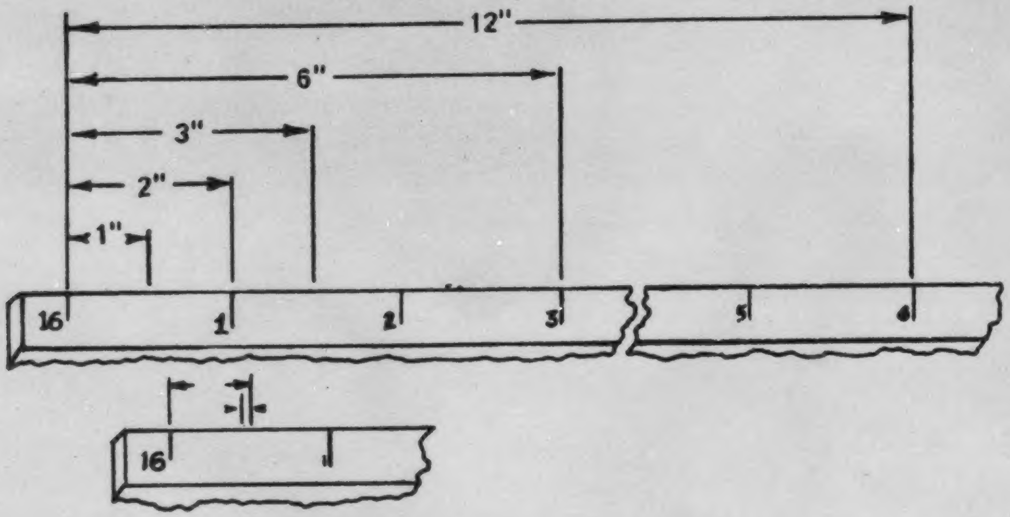
6) F = 11" + 4/16" = 11 4/16" or 11 1/4"

7) G = 11" + 12/16" = 11 12/16" or 11 3/4"

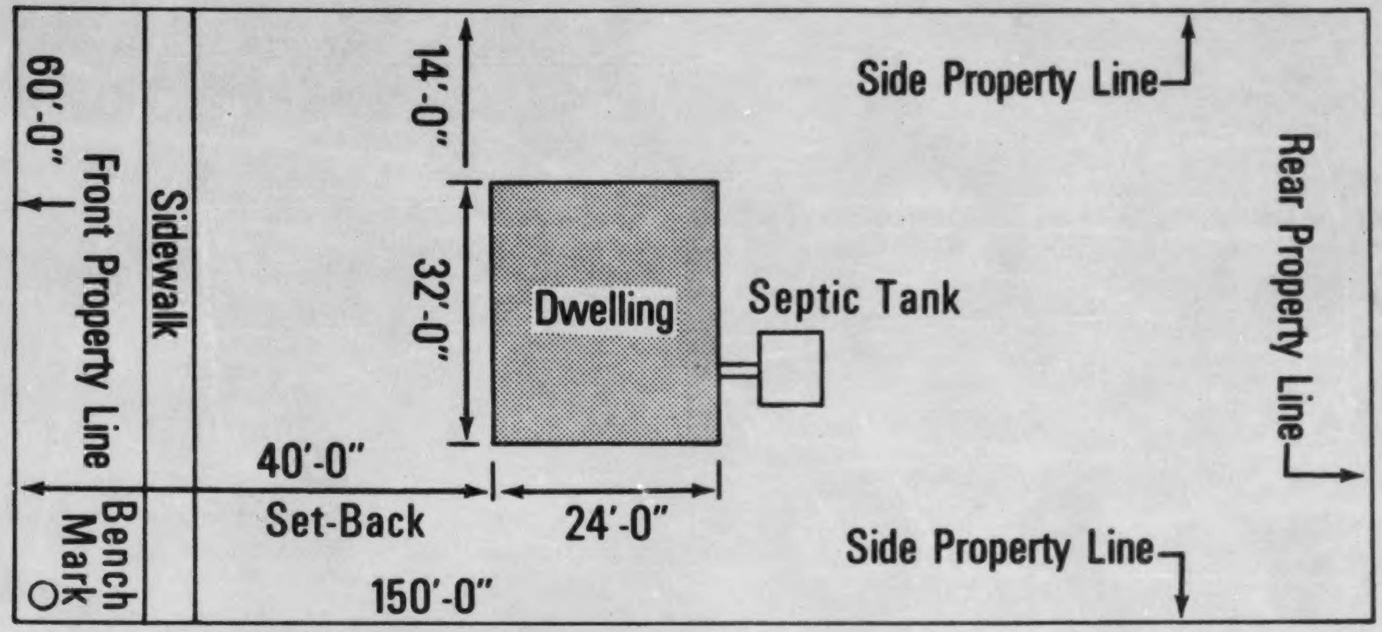
8) H = 11" = 15/16" = 11 15/16"

INFORMATION SHEET

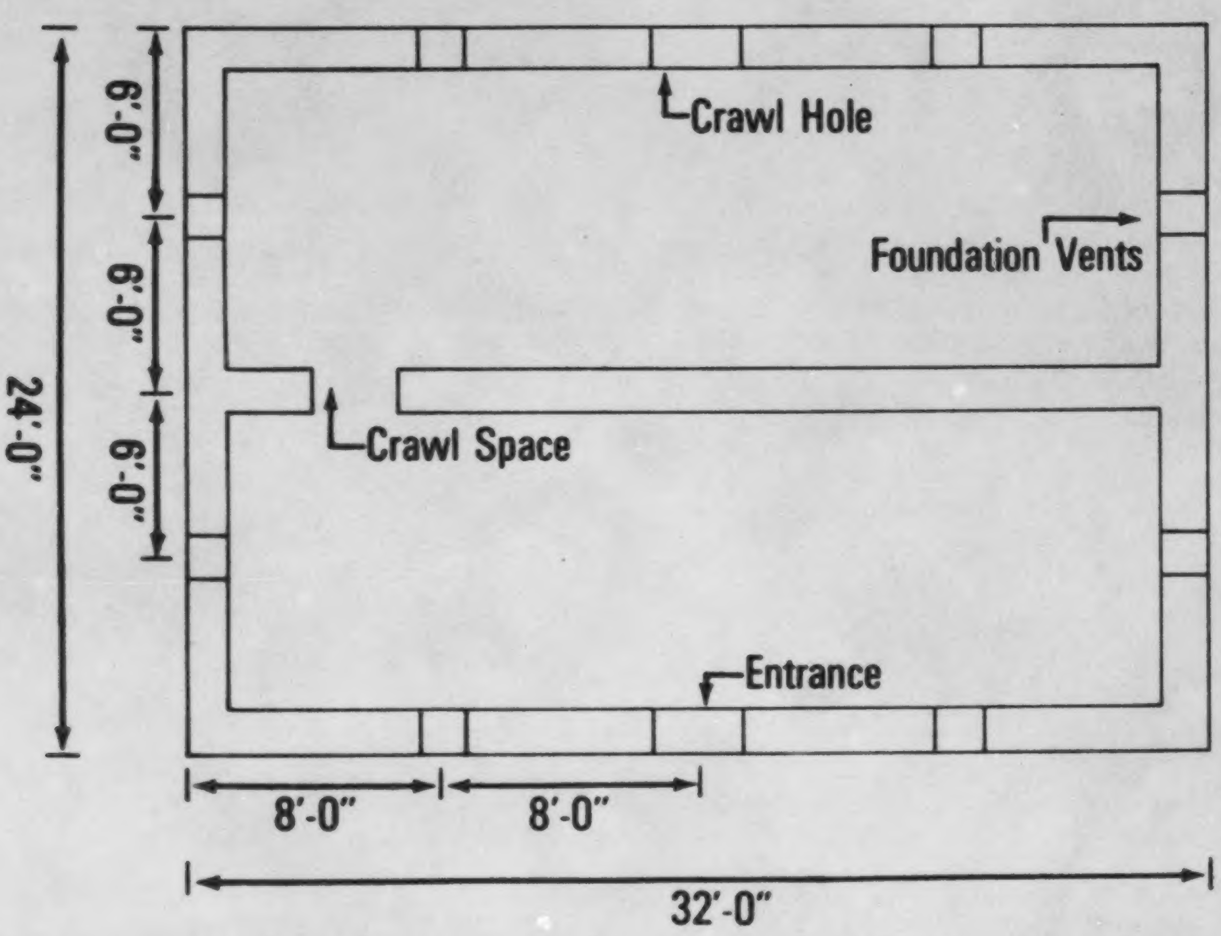
g. One-half scale or 6" represents 12"



Plot Plan


Side Property Line
14'-0"
60'-0"
Front Property Line
Sidewalk
32'-0"
Dwelling
Septic Tank
Rear Property Line
40'-0"
Set-Back
24'-0"
Bench Mark
150'-0"
Side Property Line

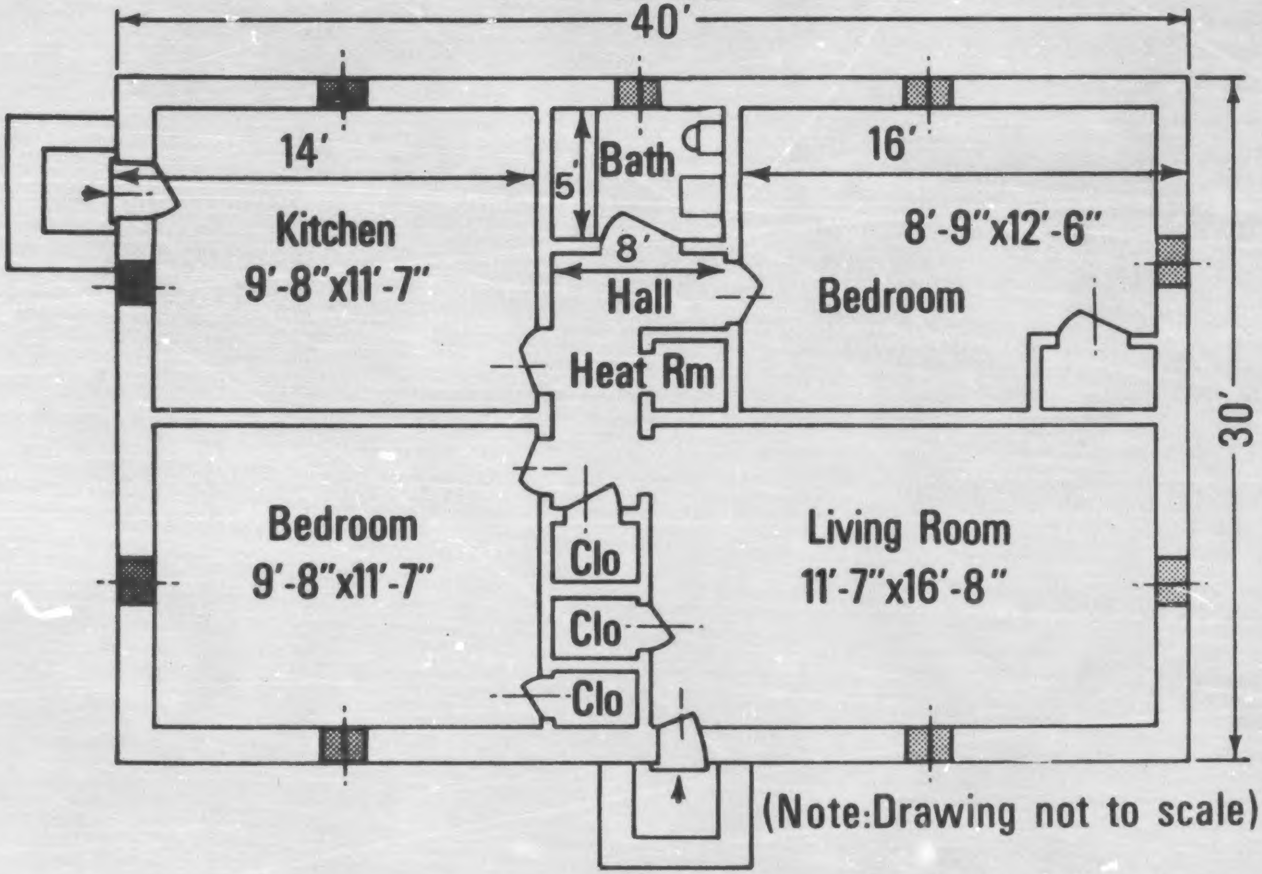
Foundation Plan



S-19-G

TM 2

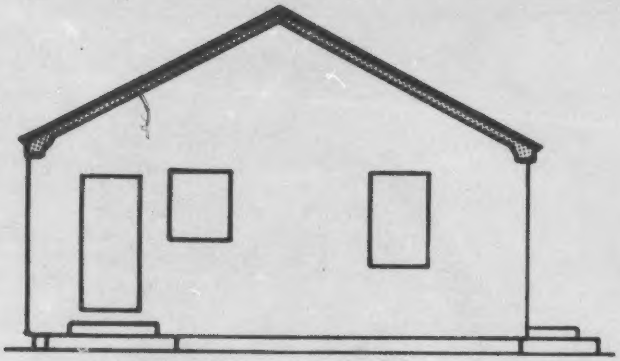
Floor Plan



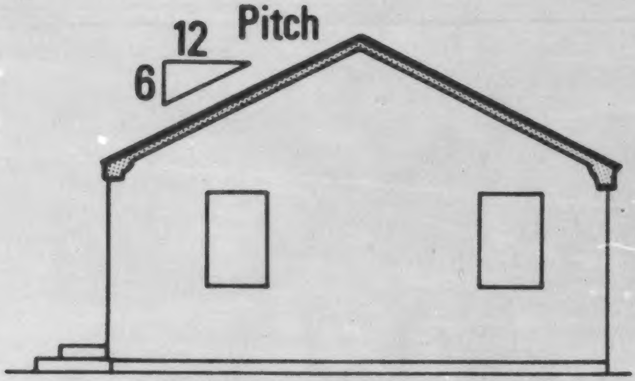
(Note:Drawing not to scale)

S-21-G

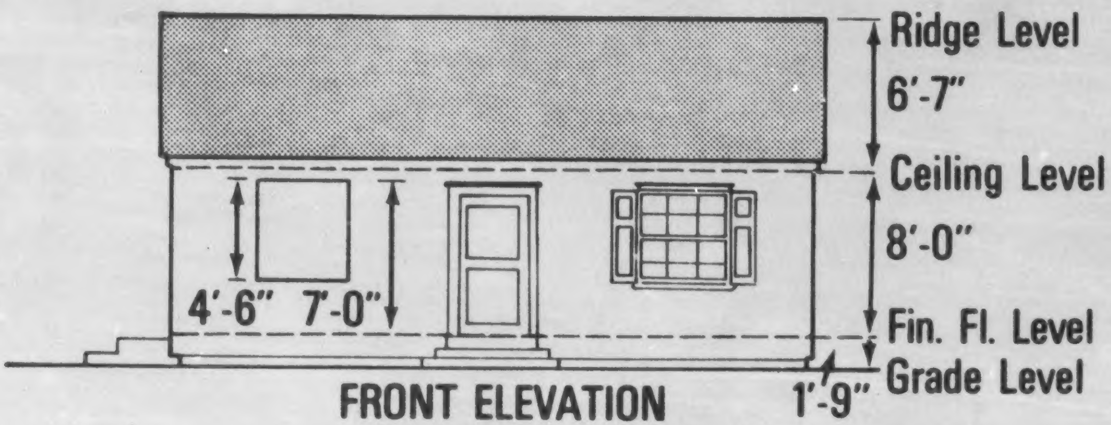
Elevations



LEFT SIDE ELEVATION



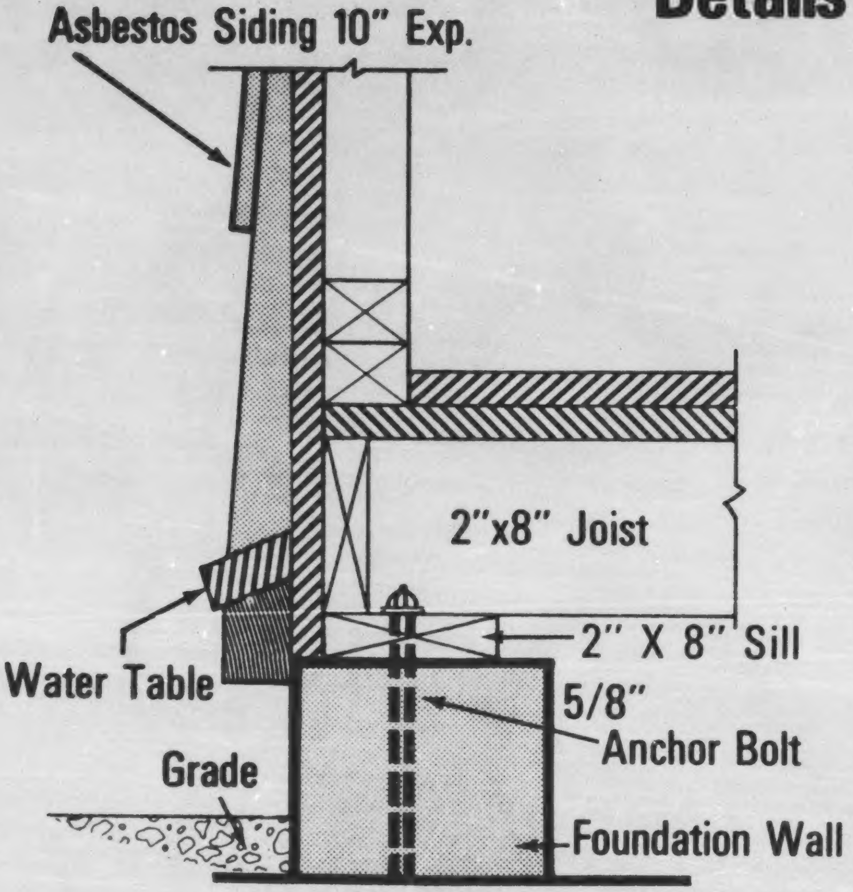
RIGHT SIDE ELEVATION



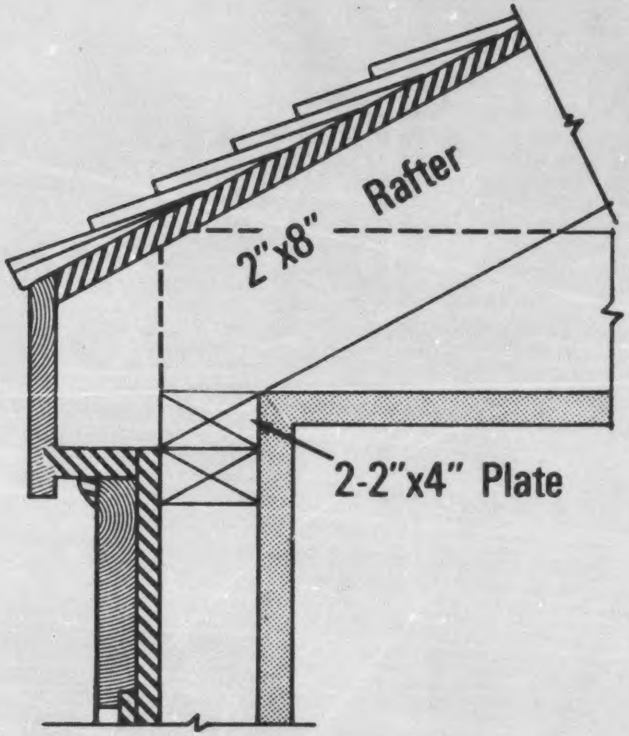
FRONT ELEVATION

Scale 1/8"=1'-0"

Details



SECTION THRU SILL

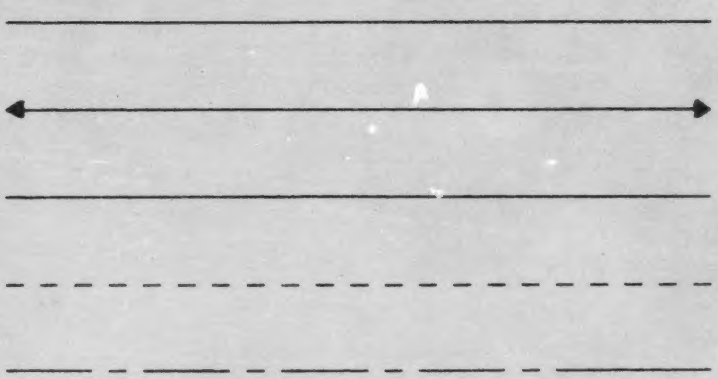


SECTION THRU CORNICE

S-25-G

TM 5

ALPHABET OF LINES



OBJECT LINE

DIMENSION LINE

EXTENSION LINE

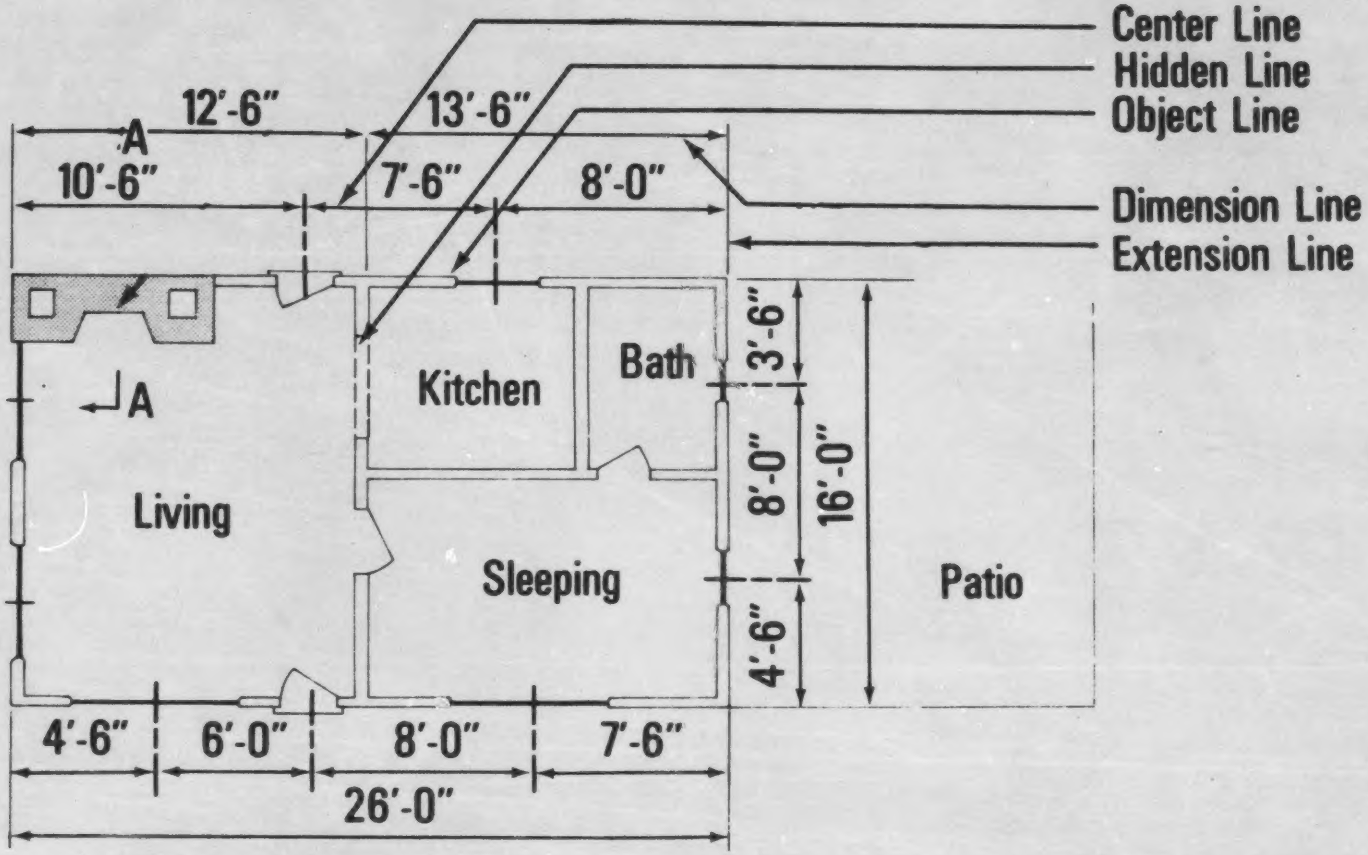
HIDDEN LINE

CENTER LINE

S-27-G

TM-6

Alphabet of Lines
(Continued)

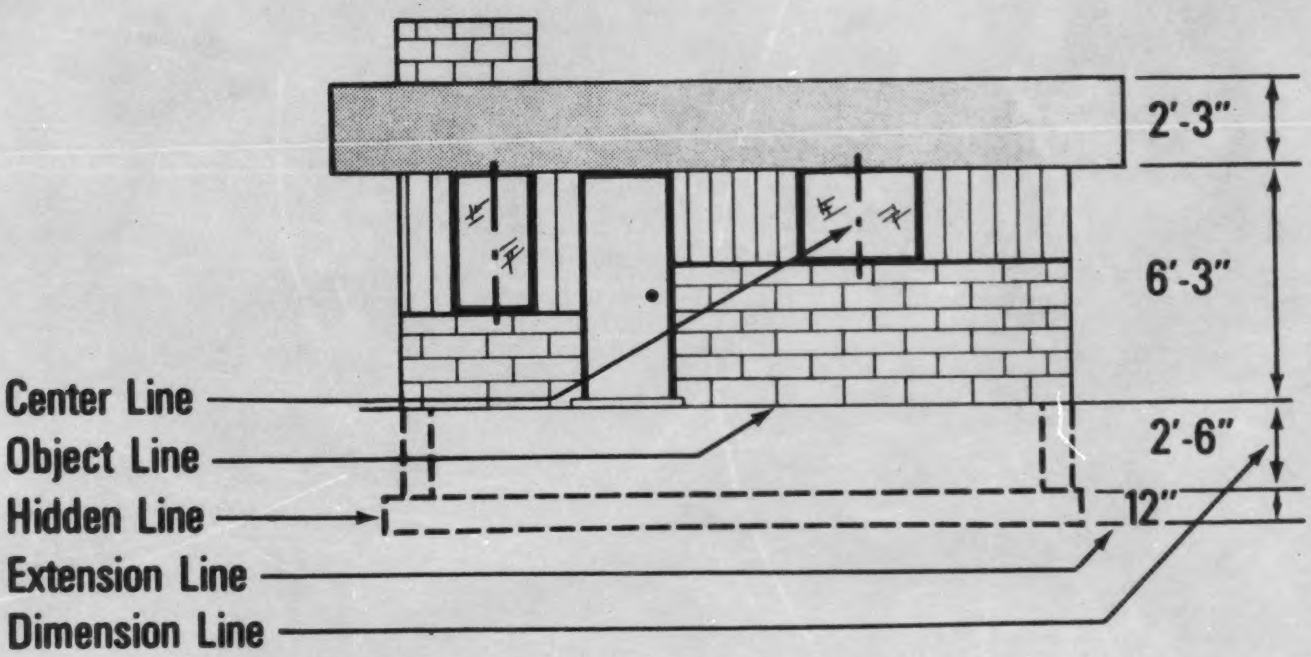


TM 7

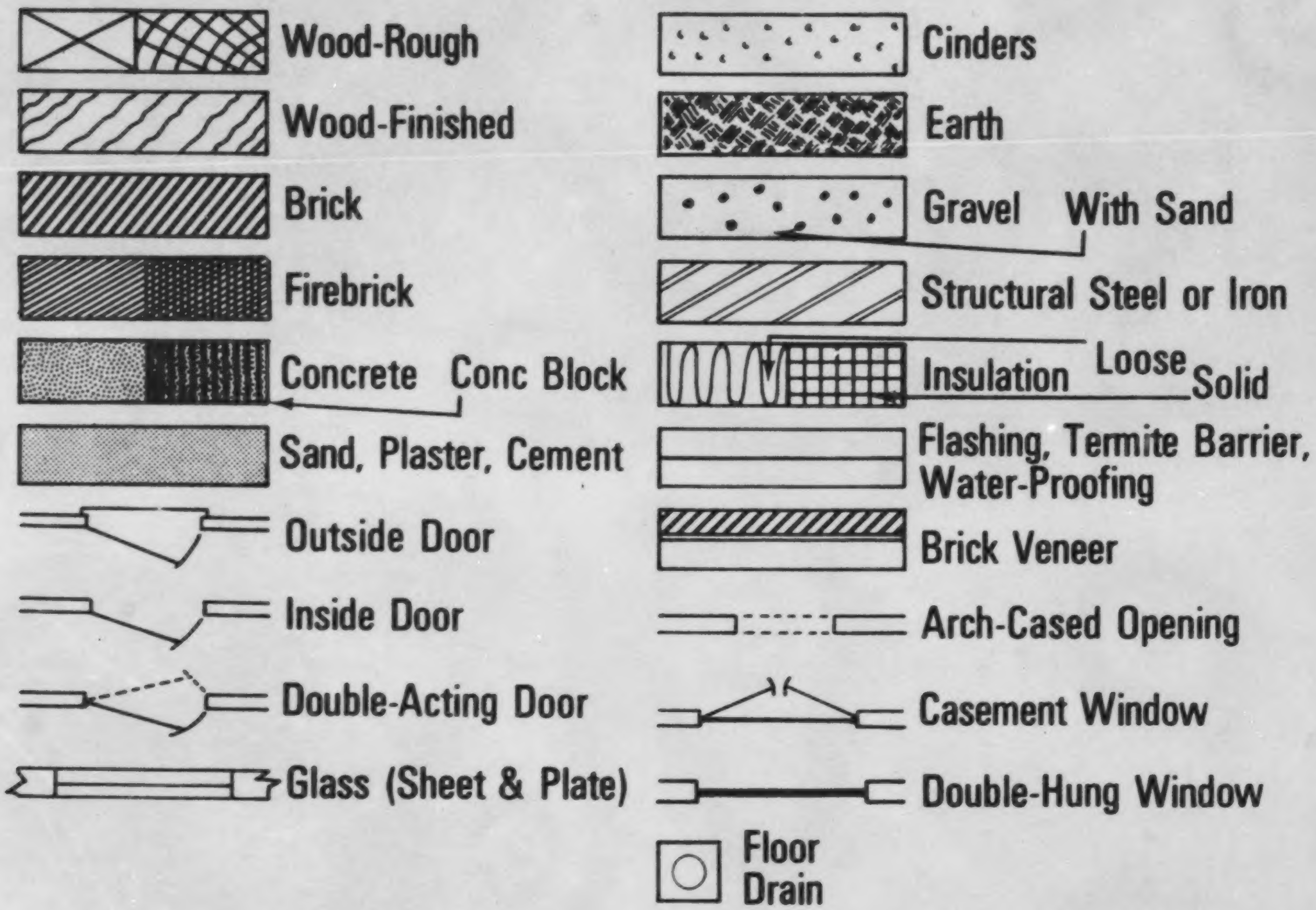
S-29-G

Alphabet of Lines

(Continued)



Floor Plan Symbols



Wood-Rough

Wood-Finished

Brick

Firebrick

Concrete Conc Block

Sand, Plaster, Cement

Outside Door

Inside Door

Double-Acting Door

Glass (Sheet & Plate)

Cinders

Earth

Gravel With Sand

Structural Steel or Iron

Insulation Loose Solid

Flashing, Termite Barrier, Water-Proofing

Brick Veneer

Arch-Cased Opening

Casement Window

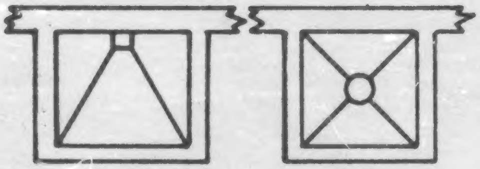
Double-Hung Window

Floor Drain

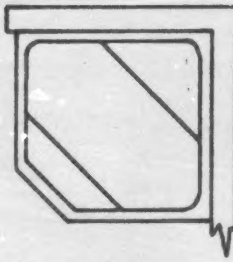
TM 9

S-33-G

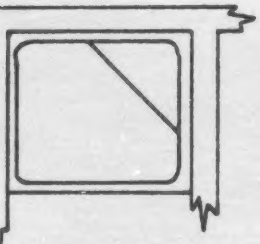
Plumbing Symbols



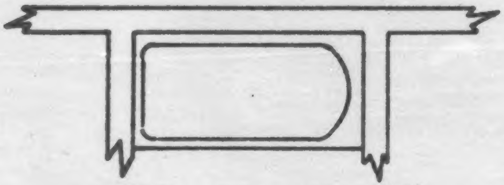
Showers



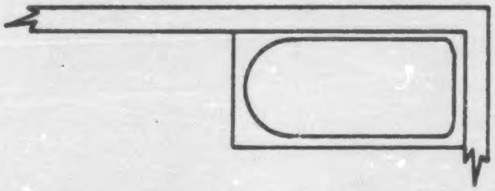
Square corner bathtub



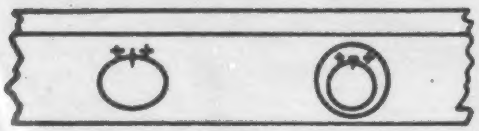
Built-in square bathtub



Built-in bathtub (Recessed)

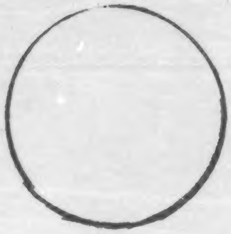


Corner bathtub

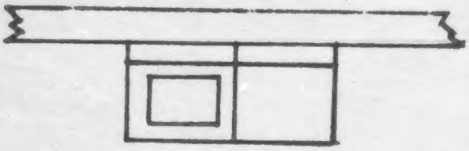


Built-in lavatories

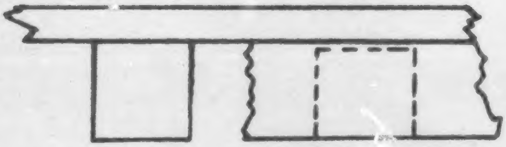
APPLIANCE SYMBOLS



WATER HEATER

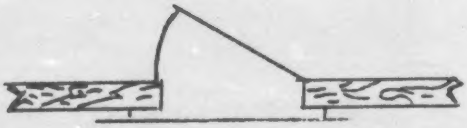


WASHER AND DRYER

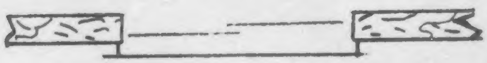


FREE STANDING AND BUILT-IN DISHWASHERS

STRUCTURAL SYMBOLS

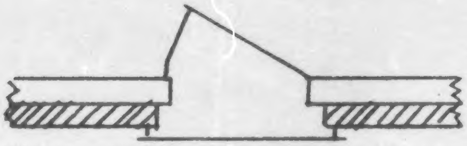


PLAN VIEW OF EXTERIOR DOOR
IN WOOD FRAME WALL

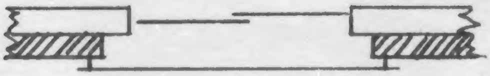


PLAN VIEW OF EXTERIOR SLIDING
DOOR IN WOOD FRAME WALL

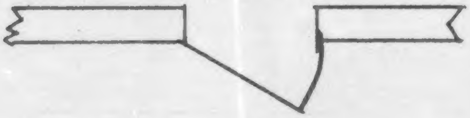
STRUCTURAL SYMBOLS (CONT.)



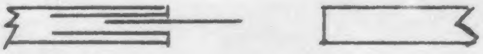
PLAN VIEW OF EXTERIOR DOOR
IN MASONRY VENEER WALL



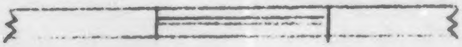
PLAN VIEW OF EXTERIOR SLIDING
DOOR IN MASONRY VENEER WALL



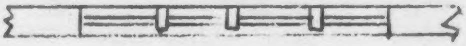
PLAN VIEW OF INTERIOR
HINGED DOOR



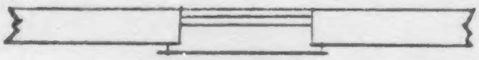
PLAN VIEW OF INTERIOR
POCKET DOOR



SINGLE WINDOW IN
FRAME WALL

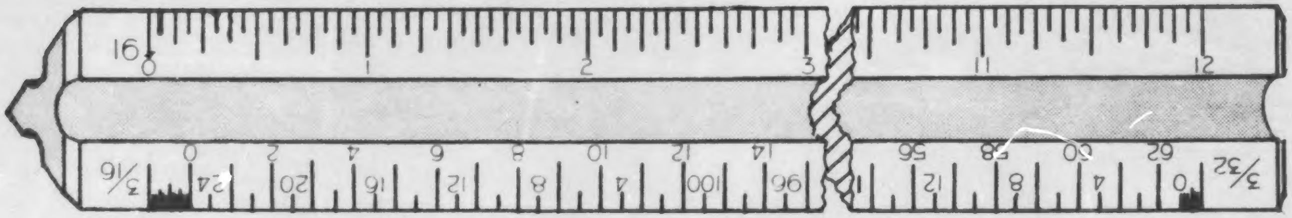


MULTIPLE WINDOWS IN
FRAME WALL

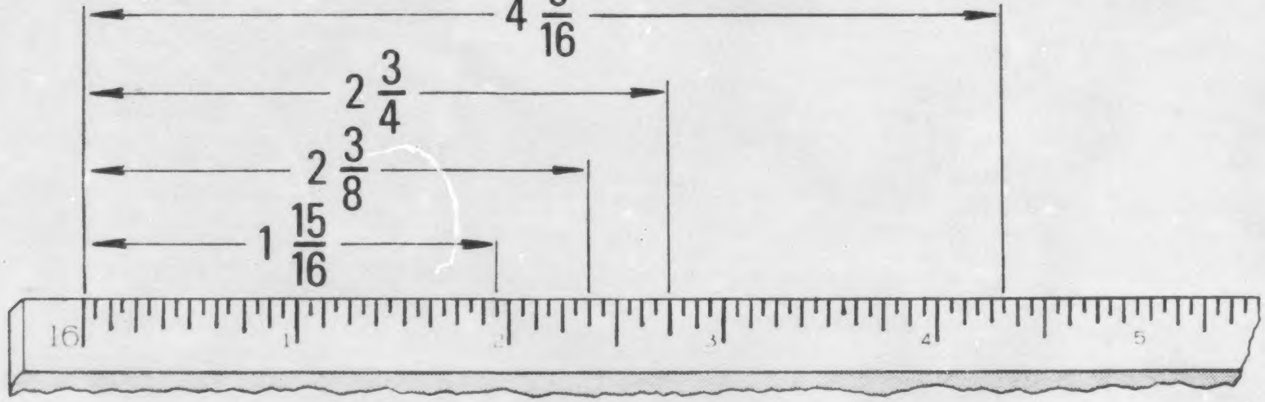


PLAN VIEW OF DOUBLE HUNG
WINDOW IN FRAME WALL

The Architect's Scale



This is how the Architect's Scale should look.

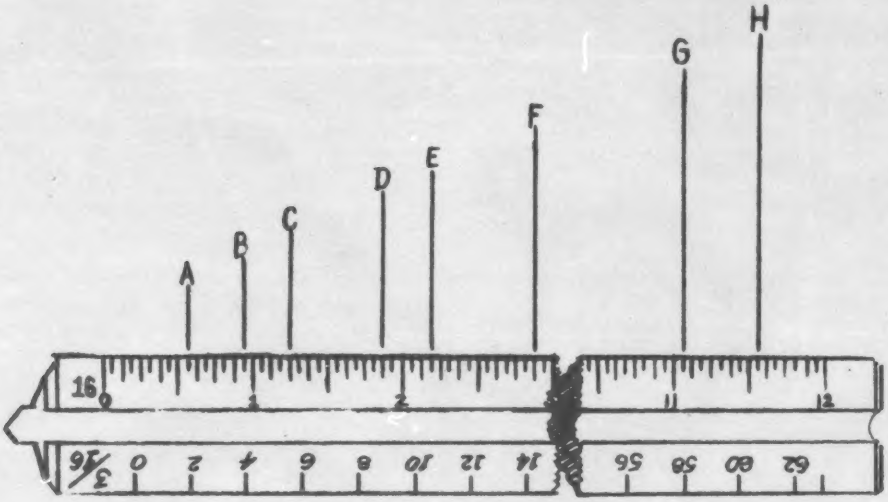


Measurements at Scale of 12" = 1'-0"

BLUEPRINT READING
UNIT I

ASSIGNMENT SHEET #1--READ THE ARCHITECT'S SCALE AT FULL SCALE OR (12" = 1'0")

Read the measurements shown below at full scale by reading the distance from "0" at left to points indicated on the scale with letters.



1. A = ________

2. B = ________

3. C = ________

4. D = ________

5. E = ________

6. F = ________

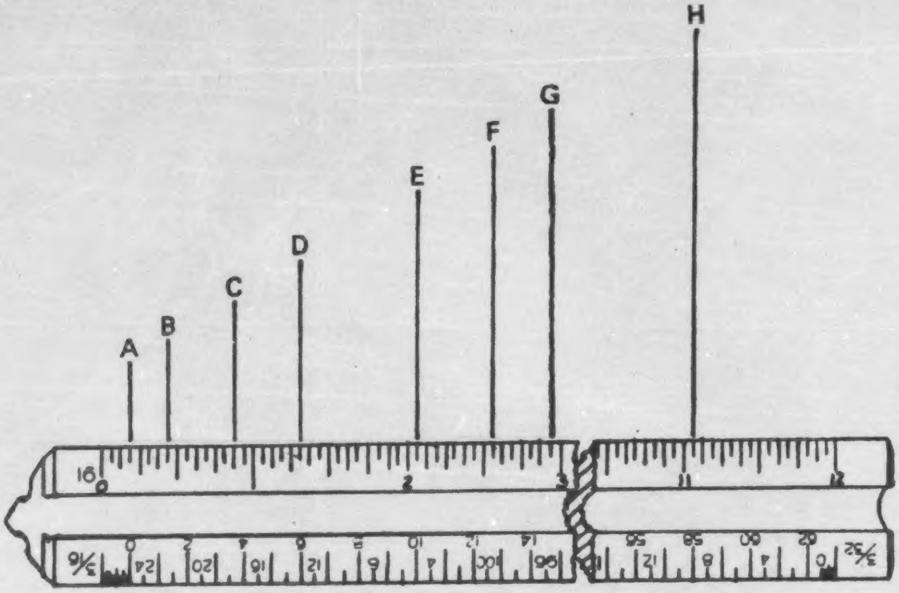
7. G = ________

8. H = ________

BLUEPRINT READING
UNIT I

ASSIGNMENT SHEET #2--READ THE ARCHITECT'S SCALE AT HALF SCALE OR (6" = 1'0")

Read the measurements shown below at half scale by reading the distance from "0" at left to points indicated on the scale with letters



1. A = ________

2. B = ________

3. C = ________

4. D = ________

5. E = ________

6. F = ________

7. G = ________

8. H = ________

BLUEPRINT READING
UNIT I

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. 9/16"
2. 15/16"
3. 1 1/4"
4. 1 7/8"
5. 2 3/16"
6. 2 7/8"
7. 11 1/16"
8. 11 9/16"

Assignment Sheet #2

1. 3/16"
2. 7/16"
3. 7/8"
4. 15/16"
5. 2 1/16"
6. 2 9/16"
7. 2 15/16"
8. 11 1/16"

BLUEPRINT READING
UNIT I

NAME___________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. A technical drawing which includes all dimensions and procedures to guide workers in the construction of a building

_____b. A detailed set of written instructions which explains the drawing and becomes part of the contract

_____c. An arbitrary sign that has been standardized and is used to represent an object, quality, or method

_____d. Collection of laws listed in booklet form that apply to a given community, state, or nation

_____e. Step by step directions which are shown in picture form

_____f. A drawing that gives complete detailed information for the construction of a single part

_____g. Set of conventional symbols covering all the lines needed to depict an object as to size an shape

_____h. The arrangement of lines and symbols to indicate the actual size for constructing the object that is represented

_____i. Horizontal cut through a building showing the foundation, rooms, partitions, windows, doors, and stairs

1. Alphabet of lines
2. Architect's scale
3. Architectural drawings
4. Blueprint
5. Building code
6. Detail view
7. Dimensions
8. Roof pitch
9. Plan view
10. Scale drawing
11. Specifications
12. Symbol
13. Working drawing
14. Elevation view

_____j. A rule divided into proportional feet and inches; a fraction of an inch is proportionally equal to one foot

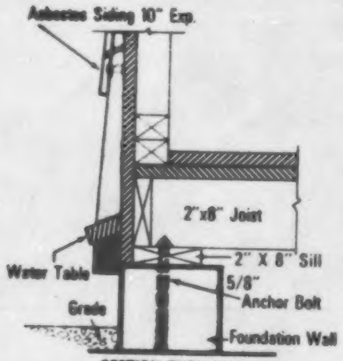
_____k. Angle of roof designed to drain rain water and also adds to beauty of the building

_____l. Drawings representing the front, sides, or rear face of a building and usually made as though the observer were looking straight at it

_____m. A copy of the original detailed drawing

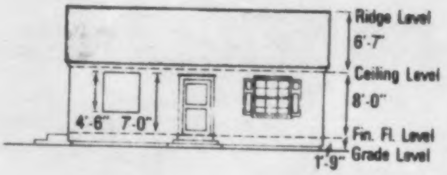
_____n. A drawing made to a size either proportionally larger or smaller than the actual size of the object represented

2. Identify the five types of architectural drawings pictured below.

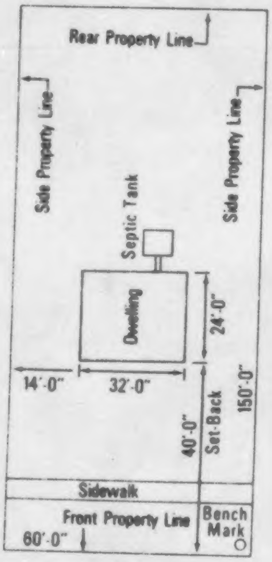


SECTION THRU SILL

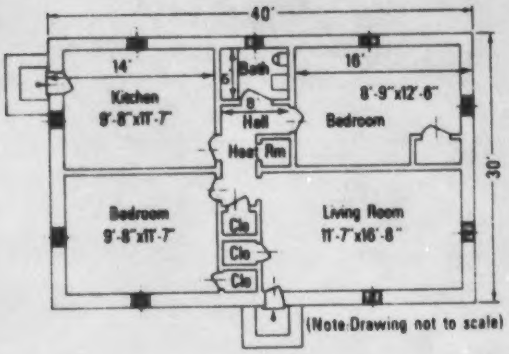
a. ______________________



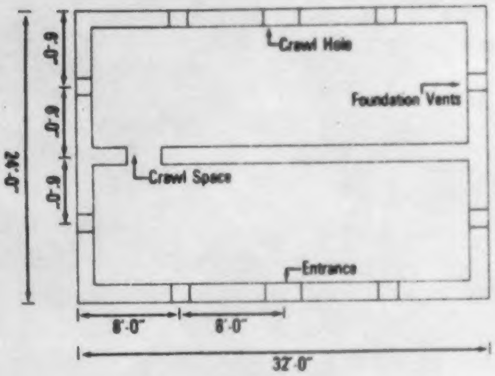
b. ______________________



c. ______________________



d. ____________________



e. ____________________

3. Identify the five types of lines on the right.

a. ______________ a. ______________

b. ______________ b. ←——————————→

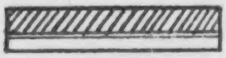
c. ______________ c. ______________

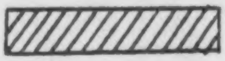
d. ______________ d. - - - - - - - - - - -

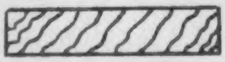
e. ______________ e. —— - —— - —— - ——

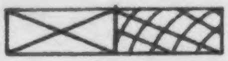
4. Match the name of the drawing symbols to the pictures of the symbols.

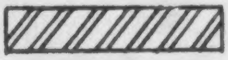
a. Floor plan

_____1)  a. Brick

_____2)  b. Wood (finished)

_____3)  c. Brick veneer

_____4)  d. Structural steel

_____5)  e. Wood (rough)

b. Electrical

_____1) Ceiling outlet a. S3

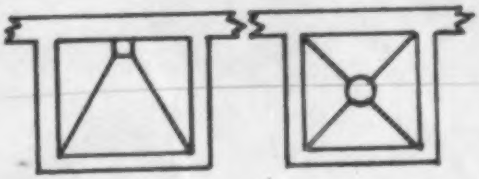
_____2) Wall bracket outlet b.

_____3) Duplex outlet c.

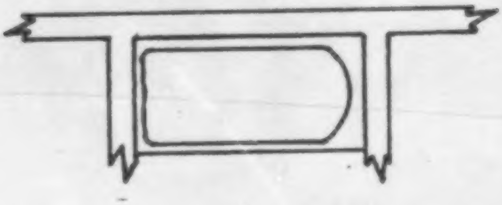
_____4) Switch (single pole) d.

_____5) Switch (3 way) e. S1

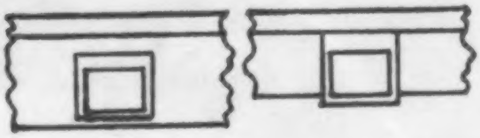
5. Identify plumbing, appliance, and structural symbols.



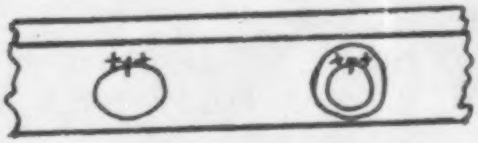
1) ______________________



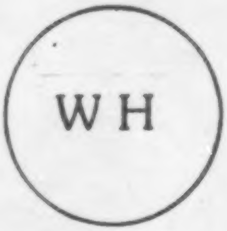
2) ______________________



3. ______________________

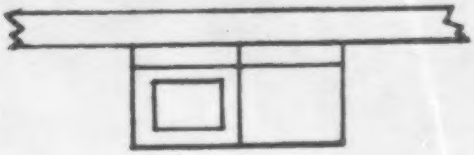


4. ______________________

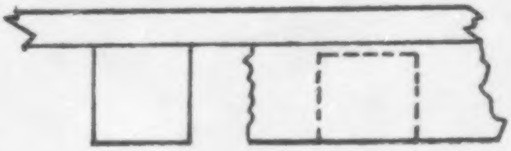


1. ______________________

b. Appliance symbols

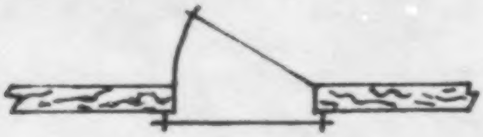


2 ______________________

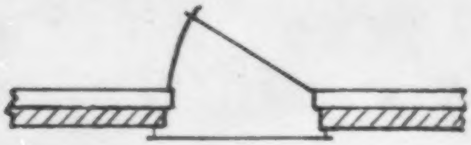


3 ______________________

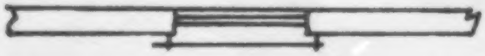
c. Structural Symbols



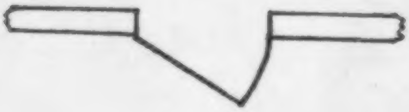
1. ______________________



2. ______________________



3. ______________________



4. ______________________

6. Match the name of the piping symbols on the right to the correct symbol.

A.____	— — — — — —	1. Cold water
B.____	______sd______	2. Vent
C.____	—— – ——— – ——	3. Gas
D.____	—— – – ——— –	4. Storm drain
E.____	_____g__g_____	5. Hot water
F.____	FD	6. Water heater
		7. Floor drain
		8. Hose bib

7. List three rules for reading the architect's scale.

a. ______________________________________

b. ______________________________________

c. ______________________________________

8. Demonstrate the ability to:

   a. Read the architect's scale at 12" = 1'-0"

   b. Read the architect's scale at half scale
   (6" = 1'-0")

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

6

BLUEPRINT READING
UNIT I

ANSWERS TO TEST

1. a. 13
   b. 11
   c. 12
   d. 5
   e. 3
   f. 6
   g. 1
   h. 7
   i. 9
   j. 2
   k. 8
   l. 14
   m. 4
   n. 10

2. a. Details
   b. Front elevation
   c. Plot plan
   d. Floor plan
   e. Foundation plan

3. a. Object line
   b. Dimension line
   c. Extension line
   d. Hidden line
   e. Center line

4. a. 1. c
   2. a
   3. b
   4. e
   5. d

   b. 1. c
   2. d
   3. b
   4. e.
   5. a

5. a. 1. Showers
      2. Built-in
      3. Built-in lavatories
      4. Built-in lavatories
   b. 1. Water heater
      2. Washer and dryer
      3. Free standing and built-in dishwasher
   c. 1. Plan view of exterior door in wood frame wall
      2. Plan view of exterior door in masonry veneer wall
      3. Single window in frame wall
      4. Plan view of interior hinged door

6. a. 2
   b. 4
   c. 1
   d. 5
   e. 3
   f. 7

7. Any three of the following:
   a. Select proper scale ratio
   b. Scale should lay flat on the surface being measured
   c. Double check all measurements
   d. Practice measuring from the center of one line to the center of the next line
   e. Do not use a scale where dimensions are available

8. Evaluated to the satisfaction of the instructor.

SYSTEM COMPONENTS
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with solar system components and describe types of storage tanks in common use. The student should also be able to identify mechanical and electrical components, valve controls, collectors, and match types of absorber materials to their proper descriptions. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with system components to the correct definitions.
2. Describe four types of solar storage tanks.
3. List three standard sizes of storage tanks.
4. Identify common components of glass and stone lined tanks.
5. Match electrical and mechanical components of electric auxiliary heaters to their correct description.
6. Match components of gas fired auxiliary heaters to their correct description.
7. Name two types of circulator pumps.
8. Name two methods of installing circulator pumps.
9. Match four types of differential temperature controls to their proper application.
10. List three options available with proportional controls.
11. Match different types of heat exchangers to their correct description.

12. Match the name of commonly used valves to their proper application.

13. Describe the purpose of expansion tanks and name three types.

14. Name six kinds of heat transfer fluids.

15. Match four types of absorber material to their proper description.

16. Name three types of flat plate collectors.

17. Demonstrate the ability to:

    a. Identify mechanical components in a solar hotwater system diagram

    b. Complete the piping runs in an incomplete diagram of a solar hotwater system

    c. Complete a wiring diagram for a dual element auxiliary heater

    d. Identify control components for a solar hotwater system

SYSTEM COMPONENTS
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet
- B. Provide student with information, assignment, and job sheets
- C. Make transparencies
- D. Discuss unit and specific objectives
- E. Discuss information and assignment sheets
- F. Review transparencies with class
- G. Discuss test procedures
- H. Review selected films and slides with class
- I. Provide assortment of fittings and system components for students to inspect
- J. Give test

II. Student:

- A. Read objective sheet
- B. Study information sheets
- C. Complete assignment sheets
- D. Take test

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheets
- C. Transparency masters
    1. TM 1--Storage Tank (No Heat Exchanger)

2. TM 2--Storage Tanks (Continued) - With Internal Heat Exchanger
3. TM 3--Storage Tanks (Continued) - With Remote Mounted Heat Exchanger
4. TM 4--Storage Tanks (Continued) - With External Heat Exchanger
5. TM 5--Storage Tanks (Continued) - With Single Electric Heater Element
6. TM 6--Storage Tanks (Continued) - With Dual Heater Elements
7. TM 7--Storage Tank Components
8. TM 8--Auxiliary Heaters Electrical Components
9. TM 9--Auxiliary Solar Tank - Electric
10. TM 10--Gas Fired Auxiliary Heater
11. TM 11--Circulator Pumps
12. TM 12--Circulator Pumps (Continued)
13. TM 13--Circulator Pumps (Continued)
14. TM 14--Controls
15. TM 15--Controls (Continued)
16. TM 16--Controls (Continued)
17. TM 17--Controls (Continued)
18. TM 18--Heat Exchanger Tube and Shell Type
19. TM 19--Heat Exchangers (Continued)
20. TM 20--Heat Exchangers (Continued) - Emersion Type
21. TM 21--Heat Exchangers (Continued) - External Wrap Around Type
22. TM 22--Heat Exchangers (Continued) - Double Augmented Type
23. TM 23--Valves

24. TM 24--Valves (Continued)

25. TM 25--Expansion Tanks

26. TM 26--Flat Plate Collectors - Trickle Type

27. TM 27--Flat Plate Collectors (Continued) - Serpentine Type

28. TM 28--Flat Plate Collectors (Continued) - Parallel Tubing Type

D. Assignment sheets

1. Assignment Sheet #1--Identify Mechanical Components in a Solar Hotwater System Diagram

2. Assignment Sheet #2--Complete the Piping in an Incomplete Diagram of a Solar Hotwater System

3. Assignment Sheet #3--Complete a Wiring Diagram for a Dual Element Auxiliary Heater

4. Assignment Sheet #4--Identify the Control Components for a Solar Hotwater System

E. Answers to assignment sheets

F. Test

G. Answers to test

II. References

A. Copper, Brass, Bronze Design Handbook, "Solar Energy Systems", Copper Development Association, Inc., Stanford, CT 06905.

B. Budnick, Jim and Richard H. Montgomery. The Solar Decision Book, Dow Corning Corporation, Midland, Michigan 48640.

C. Installation Guidelines for Solar DHW Systems in One-and-Two Family Dwellings, Second Edition, Contract H-2377, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

D. Audio-visual presentations

1. Solar Energy Processes: Theory - Part I, Library Filmstrip Center, 3033 Aloma, Wichita, Kansas 67211.

2. Solar Energy Processes: Theory - Part II, Library Filmstrip Center, 3033 Aloma, Wichita, Kansas 67211.

3. Solar Energy Processes: Systems - Part I, Library Filmstrip Center, 3033 Aloma, Wichita, Kansas 67211.

4. Solar Energy Processes: Systems - Part II, Library Filmstrip Center, 3033 Aloma, Wichita, Kansas 67211.

5. Solar Energy Processes: Implementation, Library Filmstrip Center, 3033 Aloma, Wichita, Kansas 67211.

SYSTEM COMPONENTS
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Absorber--A coated surface that absorbs the solar radiation and converts it to heat energy

B. Auxiliary heater--A separate storage tank with heat energy source other than solar. (Used as a back-up for the solar system)

C. Circulator pump--Pump used to circulate heat transfer fluids in collector and storage loops

D. Collector loop--That part of a solar system that contains the collectors, pumps, valves, etc., to circulate the transfer fluid

E. Component--An individual product that forms part of a more complex product

F. Direct radiation--Radiation that passes directly to the earth's surface

G. Diffused radiation--Radiation that is diffused or scattered by atmospheric particles, clouds, and pollution

H. Expansion tank--A small tank installed in a collector loop to prevent excessive pressure build-up of the heat transfer fluid as it expands in a closed loop

I. Flat plate collector--A device that converts the sun's radiation into heat energy on a flat surface

J. Heater element--A resistance heater unit installed in the solar or auxiliary storage tank to provide a source of electric heat energy

K. Heat exchanger--A device that permits the transfer of thermal energy from one medium to another

L. Heat transfer fluid--Liquid used to transport collected energy from one point to another in a collector loop

M. Potable water--Water free from harmful impurities, suited for human consumption

N. Sensor--A thermister device that is used with solar controls

O. Solar constant--Rate at which solar energy reaches the outer limits of the earth's atmosphere. (Rated at 429 BTU's per square foot per hour)

P. Solar control--An electrical device that controls operation of the solar system

Q. Solar radiation--Energy delivered to the earth by the sun

R. Solar storage--Provisions for storing the collected solar energy until it is needed

S. Storage loop--Piping and components between the storage tank and remote mounted heat exchanger

T. Thermister--A sensing device that changes its electrical resistance with temperature change

II. Types of solar storage tanks

A. No heat exchanger type (Transparency 1)--Potable water is circulated from the storage tank through the collector loop and back to storage

B. With internal heat exchanger (Transparency 2)--Solar heated fluid is circulated through the heat exchanger submerged in the potable water

(NOTE: Local codes may require that the heat exchanger be the double wall type with leak detection to the outside of storage tank.)

C. With remote mounted heat exchanger (Transparency 3)--Potable water from the storage tank is circulated through the heat exchanger and back to storage

(NOTE: Plumbing codes may require that this type heat exchanger be of the double wall type.)

D. External heat exchanger (Transparency 4)--Solar heated fluid from the collectors is circulated through tubing clamped or soldered to the outer surface of the storage tank

E. With single electric heater element (Transparency 5)--A single high wattage electric heating element is installed near the tank top to provide fast recovery when solar cannot maintain the use schedule

F. With dual heater elements (Transparency 6)--Two high wattage electric heating elements are installed for auxiliary heat. The heater elements permit this type storage tank to double duty as a back-up or auxiliary heater.

(NOTE: Storage tanks for domestic application will usually be glass or stone lined.)

III. Standard sizes of storage tanks

A. 62 Gallon--Light use

B. 82 Gallon--Medium use

C. 120 Gallon--Heavy use

(NOTE: Storage size will be selected on use schedule and recovery time needs.)

IV. Common components of glass and stone lined tanks (Transparency 7)

A. Tank sensors

1. Provide input to solar control for operation of circulator pump
2. Provide input to solar control for high temperature limit control
3. Provide input to solar control for speed control of circulator motor

B. Drain valve

C. Cold water inlet fitting

D. Hot water outlet fitting

E. Anode rod

F. Heater elements

G. Heater control thermostats

H. High limit safety switch

V. Components of electric auxiliary heaters

A. Electrical--(Transparency 8)

1. Junction box--Metal box with cover that serves as a connection point for field and manufacturer's wiring

2. High limit switch--A safety device that interupts power to the heater elements if tank temperature exceeds a preset point

3. Top thermostat--Controls on/off cycle of top element and interupts power to lower element when top element is in the "on" cycle

   (NOTE: Heater elements are sometimes referred to as heater "units".)

4. Top element--Provides fast recovery of hot water in top of tank

5. Bottom thermostat--Controls on/off cycle of bottom heater unit

6. Bottom unit--Provides hot water for normal use

   (NOTE: Many auxiliary heaters and storage tanks are equipped with only one heater element.)

B. Mechanical--(Transparency 9)

1. Relief valve opening--Fitting provided for the installation of a pressure/temperature relief valve

2. Hot water outlet--Fitting provided for the hot water supply to use points

3. Cold water inlet--Fitting provided for the incoming hot water line from solar storage

4. Dip tube--Permits hot water from solar storage to enter at the bottom of the tank

5. Anode rod--Magnesium rod inserted in the tank to reduce corrosion

6. Insulation--To restrict the loss of heat from the tank to the surrounding ambient

7. Top cover--To maintain spacing between the storage tank and the jacket

8. Jacket--Painted outer cover that provides spacing for insulation, protection for electric wiring and components, and space for brand name and data plate

9. Storage tank--Galvanized steel tank with a glass or stone lining to reduce corrosion of tank

VI. Components of gas fired auxiliary heaters (Transparency 10)

A. Main burner--Provides source of heat energy when solar cannot meet demand

B. Thermocouple--Provides DC power for safety valve operation

C. Safety pilot--Provides shut-off of gas input to burner if pilot light goes out

D. Temperature dial--Temperature selection knob

E. Thermostat control--Cycles main burner when water temperature matches temperature dial setting

F. Thermostat sensing element--Provides pressure difference needed to trip thermostat control when water temperature matches dial setting

G. Center flue--Provides for venting of by-products of combustion to the outside

H. Flue baffle--Provides extended contact of flue gases to flue walls for more efficient heating

I. Flue opening--Connection point for air diverter and exhaust vent

J. Relief valve opening--Attachment point for temperature/pressure relief valve

K. Hot water outlet--Connection for piping to use stations

L. Cold water inlet--Connection for piping from solar storage

M. Jacket--Outer housing of heater

N. Anode rod--Magnesium rod inserted in the tank to reduce corrosion

(NOTE: Many gas and electric heaters use two or more anode rods to control corrosion.)

O. Drain valve--A boiler valve installed at the tank bottom to flush sediment from the bottom to maintain maximum heat transfer from tank to water

(NOTE: This valve is also used to drain the tank if needed.)

VII. Types of circulator pumps

A. Direct drive type--(Transparency 11)

1. Centrifugal action
2. Direct drive from motor armature
3. Adjustable flow rate with built-in valve
4. Connected in series for increased vertical lift
5. Rated to 1/12 Hp. size
6. Available in 115 and 230 volt single phase
7. Available with bronze, plastic, cast iron, or stainless steel housing
8. Approved for operation of fluids to 250°F
9. Flow rate capacity to 17 GPM at 45 feet of head

B. Magnetic drive type--(Transparency 12)

1. Impeller is driven by magnets mounted in the stator housing and impeller
2. May be connected in series for increased vertical lift

3. Specifications sample:

Model	Max. Flow	Max. Head	Max PSI	Inlet & Outlet	Motor HP	RPM	Volts	Amps.	Phase	Watts	Hertz
809-24	3 gpm	4.1	1.8	1/2" MPT	1/100	1750	115 24	.3 2.2	Single	20	60
809 HS	5.3 gpm	11.6	5.0	1/2 MPT	1/25	3500	115 or 230	1.2 or .6	Single	80	60

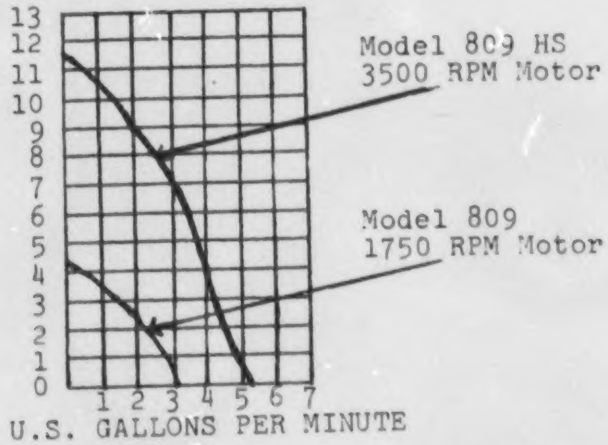
MODEL NUMBER	809	809HS	815	820	821	830	845
Head-Feet	4	11.5	15	20	8.5	30	45
Flow-GPM	3	5	5.5	12	22	15	17
Horsepower	1/100	1/25	1/25	1/8	1/20	1/5	1/3
Amps.	.3 (115V)	1.2 (115V)	1.3 (115V)	1.2 (230V)	1.8 (115V)	1.4 (230V)	3.7 (230V)
Housing Materials Available	Bronze Plastic	Bronze Plastic	Bronze Plastic	Bronze Cast Iron	Bronze Cast Iron	Bronze Cast Iron	Cast Iron

Temperatures:	250°F with water; 400 with other solutions
Hertz:	60
Voltage:	Available in 115 and 230 volts

(Courtesy of MARCH Mfg. Company)

4. Performance rated in GPM flow against feet of vertical rise of piping

5. Performance curve sample:



6. Increased flow rate capacity with increased speed of pump motor

VIII. Installation of circulator pumps--(Transparency 13)

A. Single pump installation

1. Pump selected by flow rate and vertical lift required
2. Pump must be installed below water level in tank for open loop systems
3. Maybe installed above tank in closed loop systems

B. Dual pump installation--(Transparency 13)

1. Pumps selected by flow rate and lift required
2. Connected in series for increased capacity
3. Connected as close together as possible for maximum efficiency
4. Must be installed below water level in tank for open loop systems
5. May be installed above tank for closed loop systems

IX. Types of differential temperature controls

A. Solid state control--no drain down--(Transparency 14)

1. Equipped with one tank sensor
2. Equipped with one plate sensor
3. Turns pump "on" when plate atmosphere temperature is above tank temperature by selected amount

   (NOTE: This differential will vary from 3° to 20°F generally.)

4. Turns pump "off" when plate atmosphere temperature drops to a selected amount above tank temperature

   (NOTE: This differential will vary from 15° to 5°F generally.)

5. Control turns pump "on" or "off" only - no freeze protection function

6. Control is operated on 115 VAC power supply

   (NOTE: Differential temperature controls are also available with relay "on-off" output.)

B. Solid state control--with recirculation for freeze protection--(Transparency 15)

   1. Equipped with one tank sensor

   2. Equipped with one plate atmosphere sensor

   3. Equipped with one freeze protection sensor

   4. Turns circulator pump "on" when plate temperature is higher than tank temperature by designed amount

   5. Turns pump "off" when differential between the plate and tank temperature reaches a design point

   6. Turns the circulator pump "on" to circulate water from storage through the collector loop when the freeze protection sensor reads a temperature of 40°F

      (NOTE: This value may change with different controls.)

C. Solid state control with drain down freeze protection--(Transparency 16)

   1. Equipped with three sensors

      a. Tank sensor

      b. Plate sensor

      c. Freeze protection sensor

   2. When a difference of temperature between the tank and plate sensors reaches the design value the control will turn the circulator pump "on"

   3. When the temperature difference is reduced to the design value the control will turn the circulator pump(s) "off"

   4. If the collector temperature decreases to 40°F the exposed sections of the collector loop are drained through use of a three-way solenoid controlled valve

(NOTE: The water is drained into the sewer or other selected place.)

5. When the collector temperature increases to 45°F the exposed sections of the collector loop is filled by supply water pressure

   (NOTE: The drain and refill temperature valves may change with different control systems.)

D. Solid state proportional control with choice of recirculate or drain down freeze protection--(Transparency 17)

1. Equipped with three sensors

   a. Plate sensor

   b. Lower tank sensor

   c. Upper tank sensor

2. Controlled power output to circulator pump motor to:

   a. Operate the pump at full speed when the temperature difference between the collector plate and the storage tank increases above the design value

      (NOTE: This value is generally 12° to 15°F.)

   b. Reduce the pump speed as the differential between the plate and storage tank decreases

   c. Turn the circulator pump "off" when the plate and tank temperature differential decreases to 3°F.

3. The control will turn the pump(s) "on" when the differential between plate and tank temperature increase above 3°F

   (NOTE: This value may change with different controls.)

X. Options available with proportional control

A. Freeze protection by recirculation

B. Freeze protection by drain down with dual output to control a drain down valve and make up water valve to maintain a temperature of 40° to 45°F in the collector(s) and exposed collector loop

(NOTE: These options available with other solar controls also.)

C. High temperature limit feature that cuts the circulation pump(s) off when tank temperature reaches a predetermined limit

(NOTE: Most limit switches will operate at 160°-170°F.)

D. Output control switch

1. Manual operated switch used to select mode of operation

    a. "Automatic" operation of system by solar control

    b. "Manual" operation of system by customer or technician

    c. "Off" position that overrides the solar control to prevent operation of system

    (NOTE: This switch is available as an option on some controls.)

XI. Types of heat exchangers

A. Tube and shell type--(Transparency 18)

1. Remote mounted type

    a. Fluid from storage directed through the inner tube in an upward direction

    b. Fluid from the collector loop is directed through the outer tube in a downward direction

    (NOTE: If toxic fluid is used in the collector loop, a double wall exchanger may be required to meet local codes.)

B. Co-Axial type--(Transparency 19)

1. Helical (coiled) type

2. Trombone type

(NOTE: May be single or double wall style.)

C. Emersion type--(Transparency 20)

1. Coiled type exchanger mounted inside the storage tank

2. Heated fluid from the solar collector(s) is pumped through the heat exchanger coil and dissipates heat into the storage water

(NOTE: If toxic fluid is used in the collector loop a double wall exchanger may be required to meet local codes.)

D. External wrap-around type--(Transparency 21)

1. Single wall tubing wrapped around the outer tank liner and clamped or soldered to the tank for maximum heat transfer

2. The inlet end of the exchanger will be at the top of the coil for counter flow results

(NOTE: A heat transfer compound may be used to increase transfer between the exchanger and tank.)

E. Double augmented type--(Transparency 22)

1. Tube and shell design with the inner tube rifled for more efficiency

2. A specially designed tube is fitted over the inner tube to form a double wall feature with leak detection on the outside of the exchanger

3. The outside of the special tube is knurled to provide increased surface contact for faster heat transfer

4. A larger tube is installed over the inner tubes to complete the exchanger

(NOTE: The inside tube is recommended to carry the fluid to be heated.)

XII. Commonly used valves and their application

A. Boiler drain valve--(Transparency 23)

1. Installed at the bottom of solar storage tanks and auxiliary heaters for draining and flushing

2. Installed in storage and collector loops for filling, draining, or flushing

B. Gate valve--(Transparency 23)

1. Installed in storage and collector loop piping for:

   a. Isolation of pumps or other components

   b. System shut-down

   c. Flow rate adjustments

   d. Manual fill valves

   e. By-pass manifolding

C. Globe valve--(Transparency 23)

1. Installed in storage and collector loop piping for:

   a. Flow rate control down stream from pumps

D. Check valves--(Transparency 23)

1. Installed in the collector and/or storage piping as required to prevent back flow of hot water or heat transfer fluid

E. Union type isolation valve--(Transparency 23)

1. Installed between the circulator pump and system piping to isolate the pump and permit fast installation or replacement

F. Flange type isolation valve--(Transparency 23)

1. Installed between the system piping and pumps or other components for ease of installation and/or replacement

G. Vacuum relief valve--(Transparency 24)

1. Installed at a high point in the collector loop on drain down systems to permit atmospheric pressure to enter the loop to insure drain down when the pump turns off

H. Automatic air vents--(Transparency 24)

1. Installed at a high point in the collector loop to permit air bubbles to escape without loss of transfer fluid

   (NOTE: A float valve in the air vent valve rises with the fluid level forcing the air out before closing the opening.)

I. Pressure relief valve--(Transparency 24)

1. Installed in the collector loop to allow heat transfer fluid to be vented in case the valve setting is exceeded

   (NOTE: Non-circulating fluids in collectors or sections of piping may reach dangerous pressures under stagnant conditions.)

J. Temperature and pressure relief valve--(Transparency 24)

1. Installed at the top of storage tanks and auxiliary heaters to protect against temperatures or pressures that exceed the valve settings

2. The valve will reclose automatically when the temperature or pressure decreases below the valve release setting

   (NOTE: Valve settings are usually set at 125 PSI and 210°F.)

K. Mixing valve--(Transparency 24)

1. Installed between the source of hot water and the supplied points

   (NOTE: Mixing valves are also referred to as tempering valves.)

2. The valve is installed in both the hot water source line and the cold water supply line and mixes the two to supply hot water at a selected temperature

   (NOTE: Mixing valves are adjustable from 110°F to 160°F.)

XIII. Expansion tanks

A. Purpose--To prevent high pressure build-up of the heat transfer fluid as it expands in a closed loop collector system

B. Types of expansion tanks

1. Bladder or diaphragm type--(Transparency 25)

   a. Contains a flexible diaphragm with an air charge on one side

   b. As the heat transfer fluid increases in temperature and volume the diaphragm compresses the air charge making room inside the expansion tank for the expanding fluid

   c. Tanks with butyl rubber or neoprene diaphragm are not normally recommended for use with silicone transfer fluids

   d. Tanks with butyl rubber diaphragms are not recommended for use with water/glycol transfer fluids

   e. May be installed in either the upright or downward position

      (NOTE: There is less heat loss with the tank in the downward position.)

   f. Recommended for all closed loop systems with heat exchangers

2. Nondiaphragm expansion tank--(Transparency 25)

   a. Open type nondiaphragm tanks

      1. Must be mounted at or near the highest point in the system

      2. The air chamber must be at the top of the tank

         (NOTE: Galvanized expansion tanks are not recommended for use with water/glycol mixtures.)

3. Closed nondiaphragm tank--(Transparency 25)

   a. May be located at any point in the system

      (NOTE: Expansion tanks should be installed after the system has been pressure tested to avoid possible damage to the tank.)

XIV. Heat transfer fluids

A. Potable water

1. Potable water may be used in:
   - a. Closed loop systems that:
     1. Circulate water from solar storage through the collector loop and back to storage
     2. Provide drain down freeze protection by draining the collector loop into the sewer or other selected area
     3. Provide freeze protection by draining the collector loop back into solar storage with an air head in top of the storage tank that sweeps water from the loop back into the tank on each "off" cycle of the pump
   - b. Drain back open loop system that:
     1. Circulates water from a nonpressurized tank with a heat exchanger through the collector loop and back to the vented tank
     2. Provides freeze protection by drain down of the collector loop each time the pump turns off

        (NOTE: Bronze or stainless steel pumps should be used .)

B. Distilled water

1. Used in open loop systems with heat exchanger and vented tank for drain back
2. Not as corrosive as supply water
3. System components must be matched to perform with water

C. Water/ethylene/glycol mixture

1. This transfer fluid is toxic and:
   - a. Should be used with a double wall heat exchanger
   - b. Solution concentration should be checked on a regular schedule for breakdown of the inhibitors

   - c. Used in closed loop collector systems for freeze protection
   - d. System components and piping should be properly selected for use with this type fluid
   - e. Requires the use of inhibitors

D. Water propylene/glycol mixture

1. This transfer fluid is toxic and:
   - a. Should be used with a double wall heat exchanger
   - b. Used in closed loop collector systems for freeze protection
   - c. System component should be matched to this type fluid
   - d. The solution concentration requires periodic checks

E. Silicone heat transfer fluids

1. Are inert and will not cause galvanic corrosion
2. Will not degrade roofing materials
3. Have lower specific heat values than water
4. Require larger circulator pumps than water to move increased flow rate required
5. Will leak from flaws too small for water to escape
6. Silicone fluids have a high flash point and very low freezing point
7. Are used in closed loop collector systems with double wall heat exchangers
8. Require no periodic check on fluids for inhibitor problems
9. Are non-corrosive in properly designed systems

F. Freon heat transfer fluids

1. Freon is a trade name for fluorocarbon refrigerant
2. Refrigerants are used in solar collector systems for the same reasons they are used in air-conditioning equipment
    a. They are stable and non-corrosive
    b. Non-flammable and low in toxicity
    c. Non-freezing
    d. Does not require direct sun input for heat gain
    e. Requires no moving parts on gravity return systems
    f. Requires no periodic system maintenance

XV. Absorber materials

A. Coatings

1. Flat black paint--a high temperature paint that may be brushed or sprayed on
2. Black chrome--a high temperature absorber with good efficiency at high collector temperatures
3. Selective coatings--special designed absorber for high temperature efficiency

B. Fabric--inorganic material with high energy transmitting ability

(NOTE: This type absorber material may form the entire absorber plate.)

XVI. Flat plate collectors

A. Trickle type--(Transparency 26)

1. Non-pressurized collector using an inorganic fabric as the absorber plate
2. Water is used as the heat transfer fluid
3. A separate vented tank is required for the collector loop

4. A heat exchanger is required for heat transfer to the storage water
5. No freeze protection is required for the collector due to drain back each time the circulator pump turns off
6. Larger pumps are required to move the transfer fluid from the vented tank to the top of collectors
7. Heat transfer fluid is pumped to the top of collectors and allowed to drain, by gravitational pull, through the plate and back to the accumulator tank
8. The supply line to the collectors must be well insulated to prevent freezing above the drain down point
9. No pressure relief valve or expansion tank needed for this type system

B. Serpentine coil collector--(Transparency 27)

1. A single run of tubing is used to form the absorber plate
2. The plate may be coated with:
    a. Flat black paint
    b. Black chrome
    c. Selective coating
3. May be used in closed loop or drain back systems
4. Tubing may be bonded to copper or aluminum sheet for increased efficiency

C. Parallel tube collector--(Transparency 28)

1. Parallel runs of tubing are connected to a common inlet and outlet manifold
2. The inlet and outlet tubes are normally on opposite ends of the absorber plate
3. The tubing and manifolds may be bonded to copper, steel, or aluminum sheets for increased efficiency

4. The absorber plate is coated with an absorber material by:

   a. Spraying

   b. Brushing

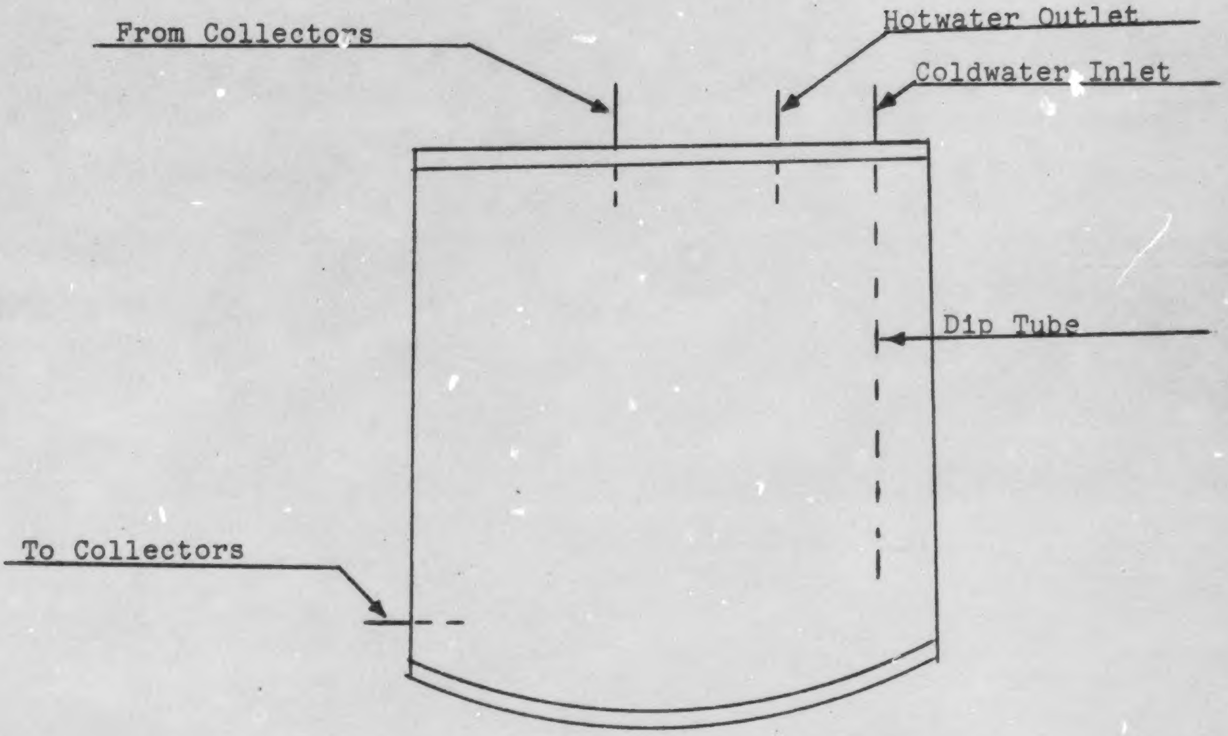
   c. Electro-plate process

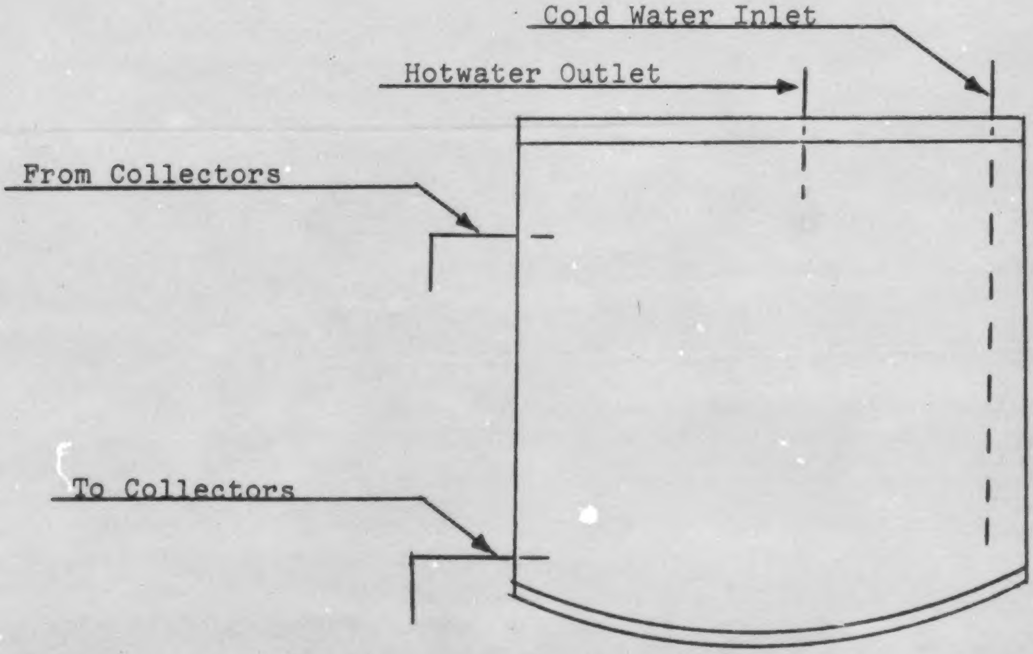
5. The absorber plate is assembled in an aluminum or wood framing with insulation and glazing to form a flat plate collector

   (NOTE: Galvanized steel is also used to form the collector frame.)

6. May be used in closed or drain back collector loop

STORAGE TANK
(NO HEAT EXCHANGER)





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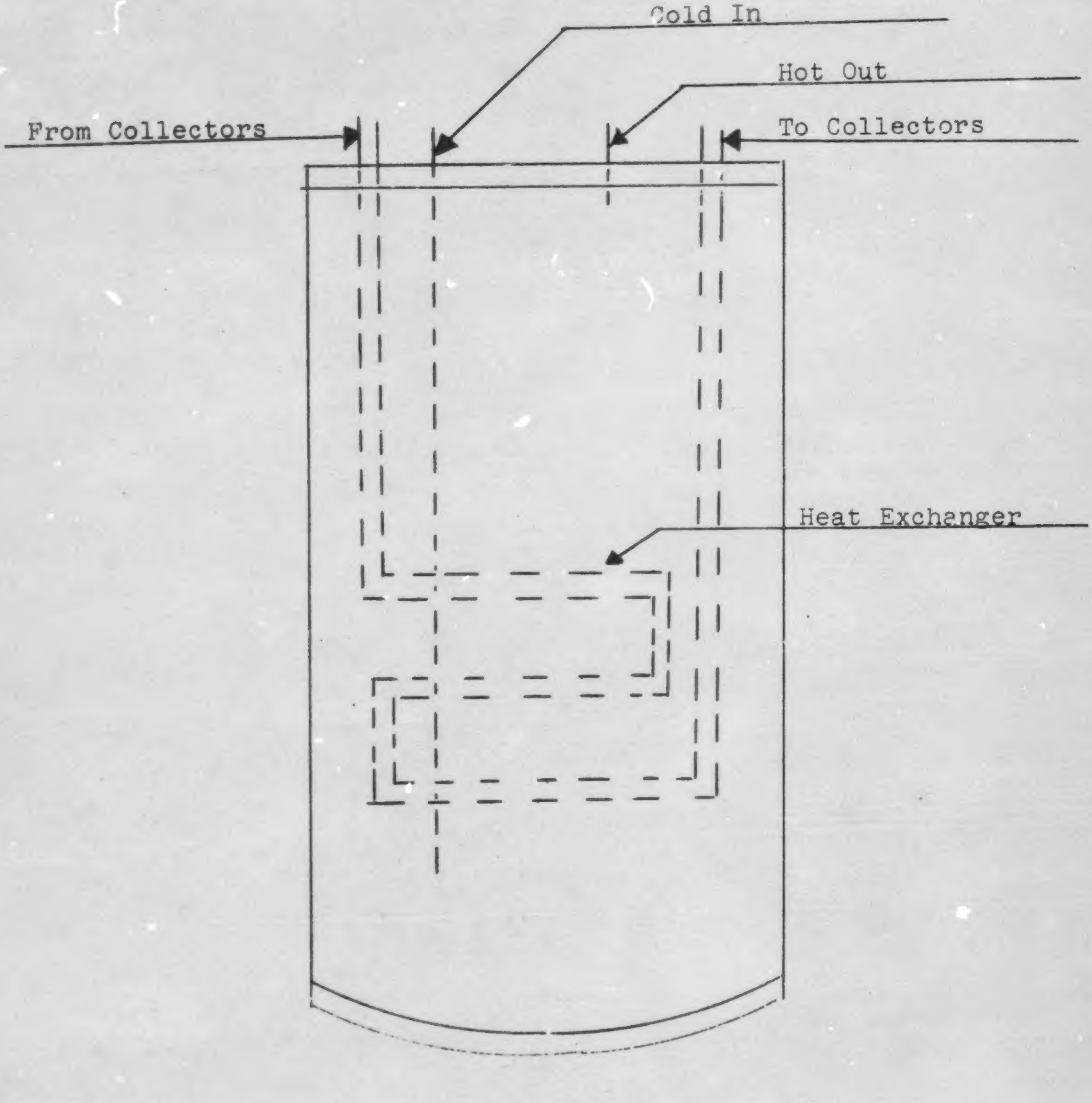
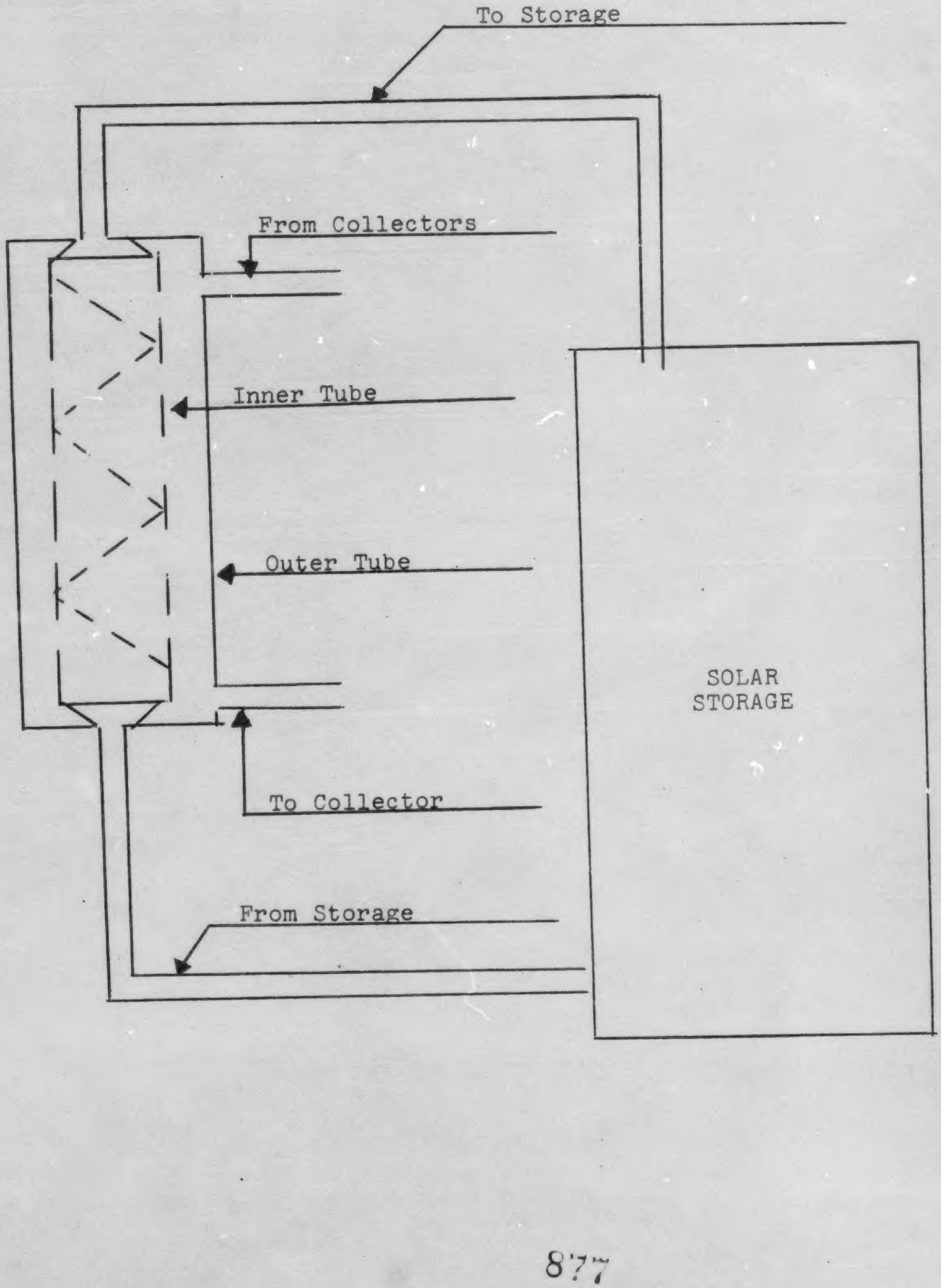
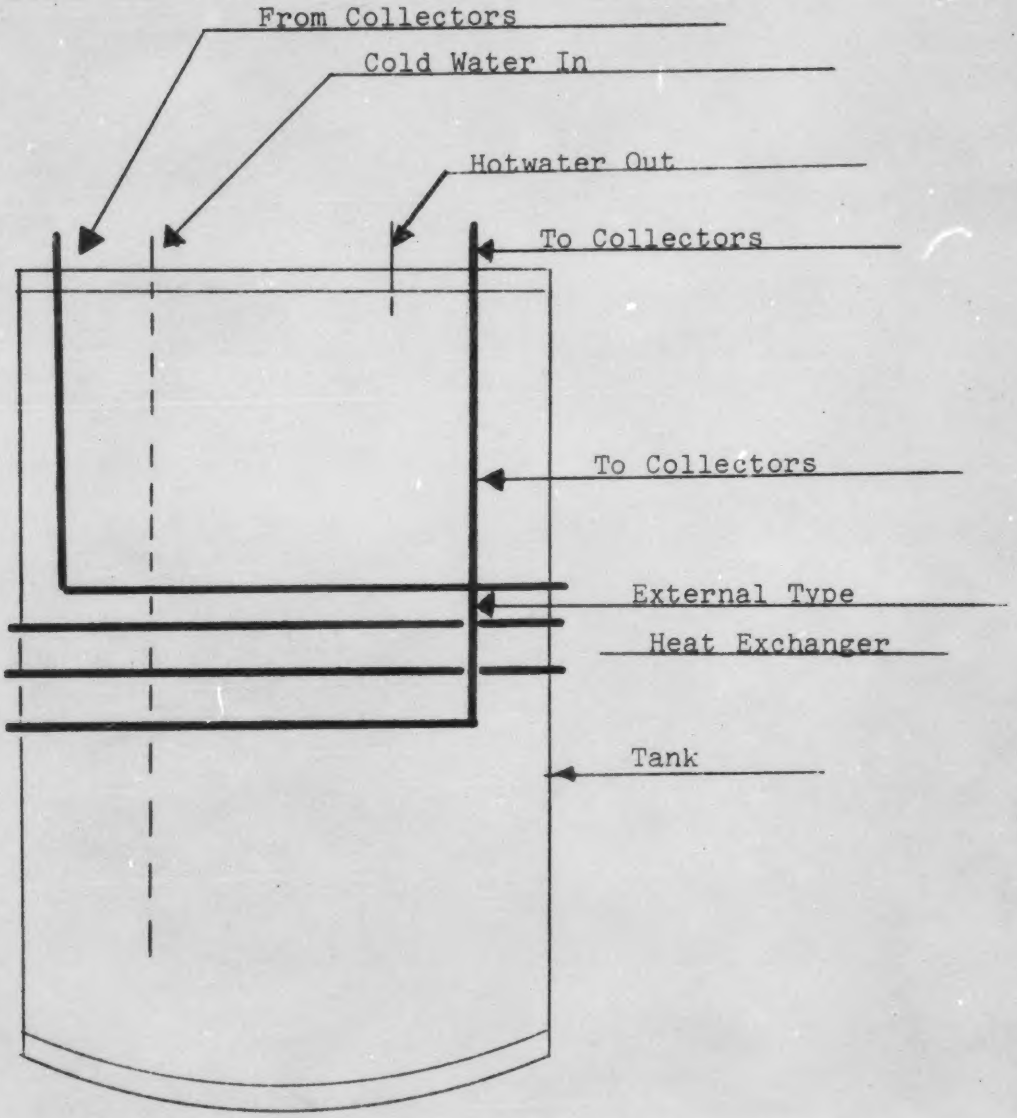
STORAGE TANKS
(CONTINUED)
WITH INTERNAL HEAT EXCHANGER



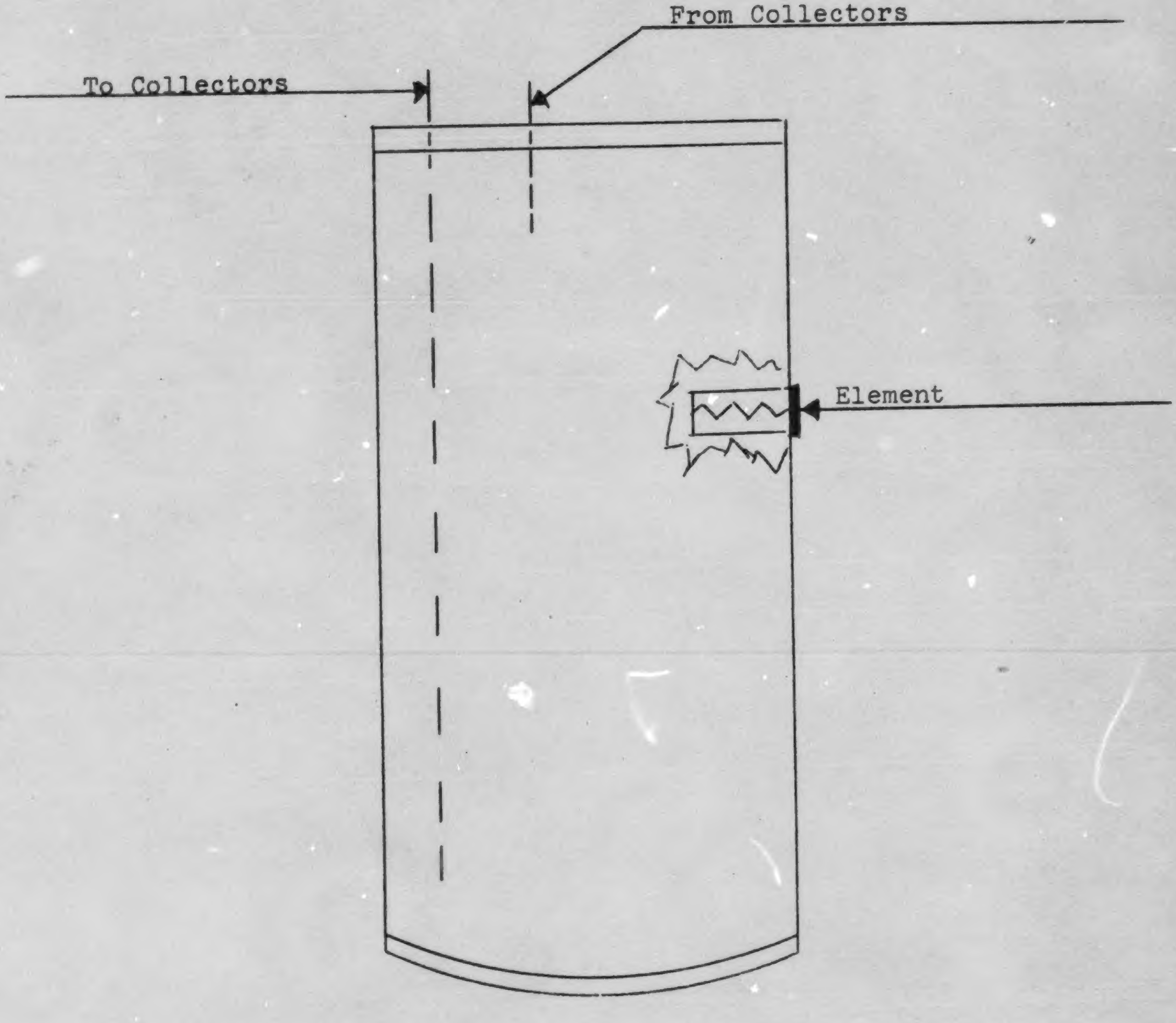
STORAGE TANKS (CON'T)
WITH REMOTE MOUNTED HEAT EXCHANGER



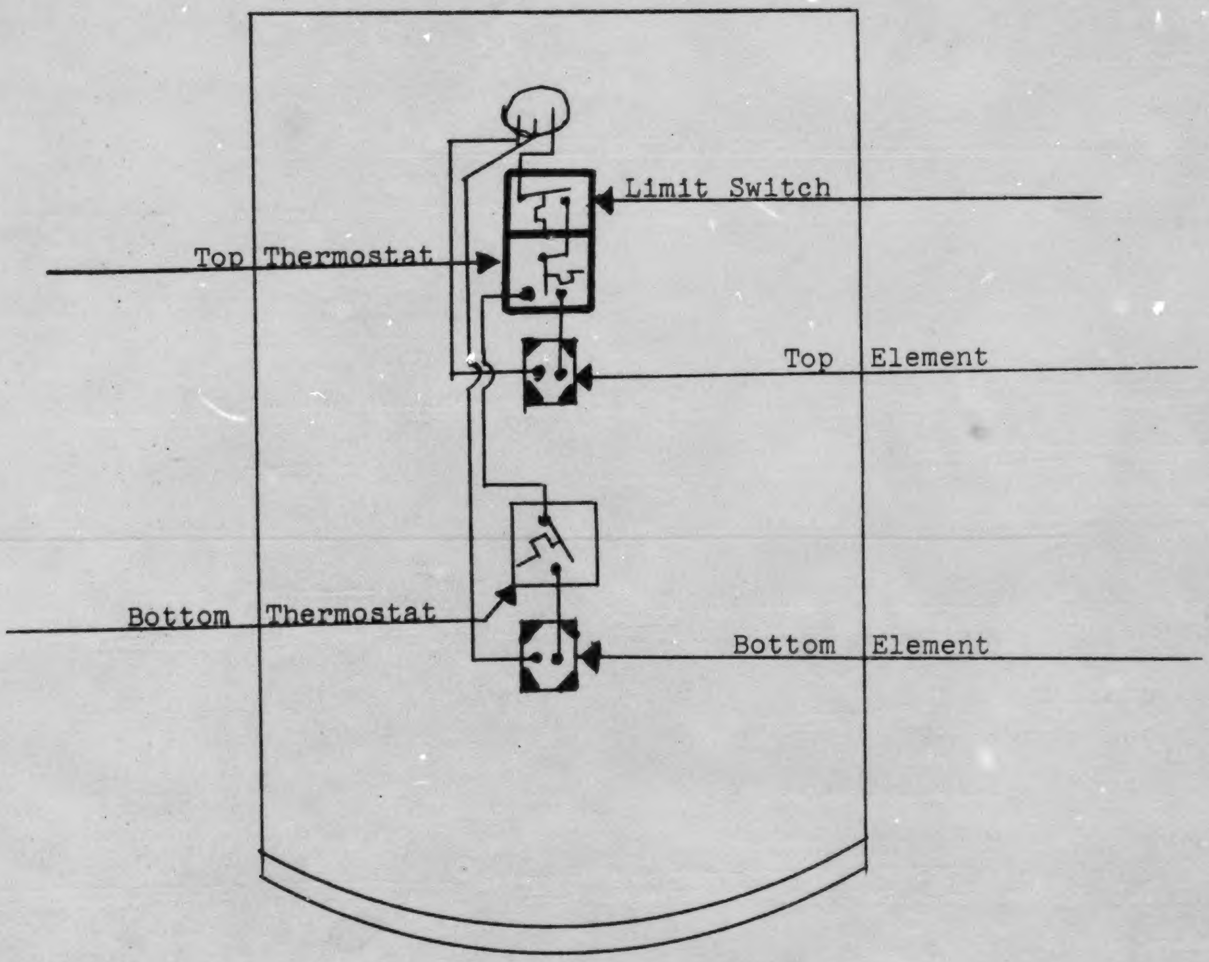
STORAGE TANKS (CON'T)
WITH EXTERNAL HEAT EXCHANGER



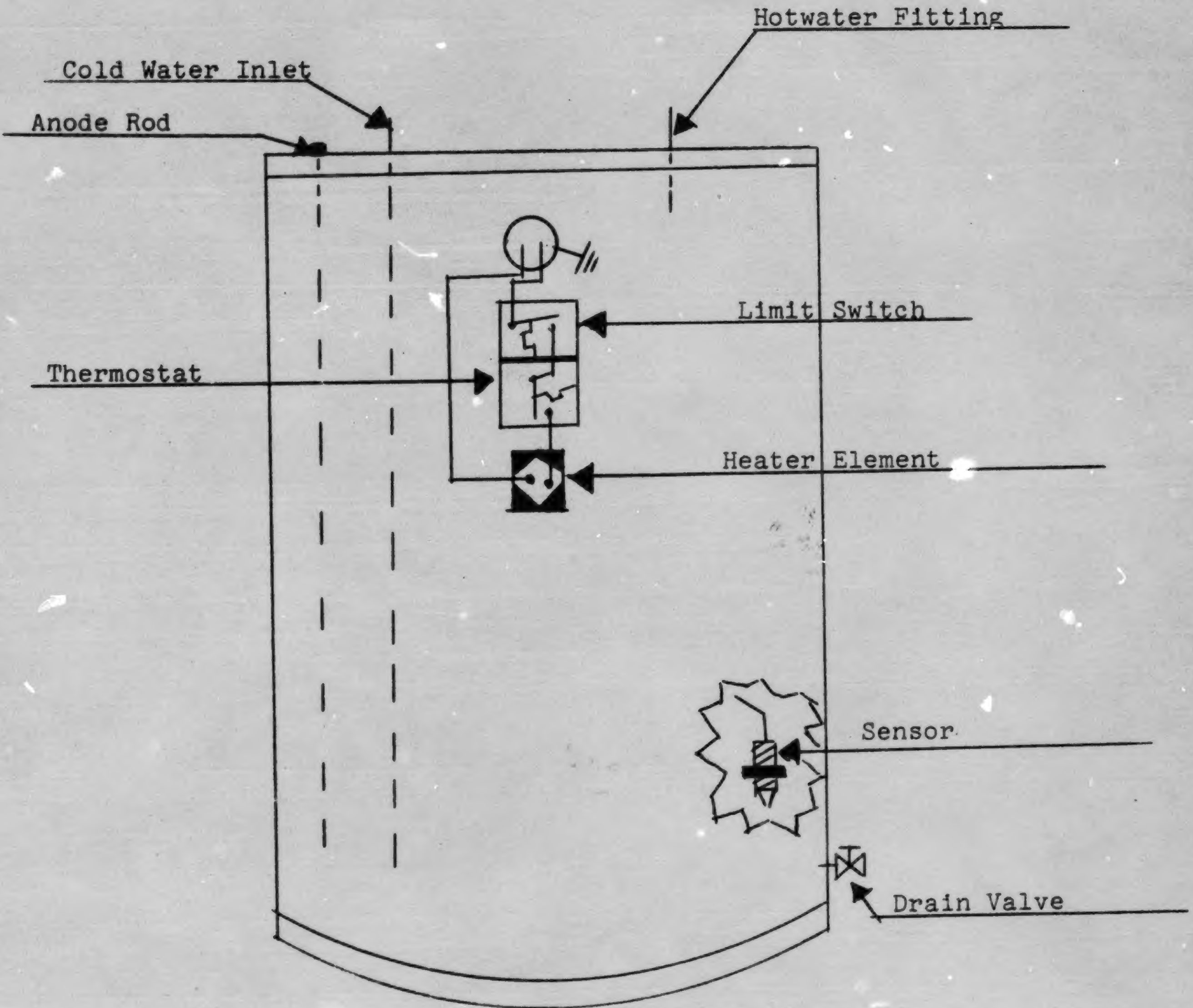
STORAGE TANKS (CON'T)
WITH SINGLE ELECTRIC HEATER ELEMENT



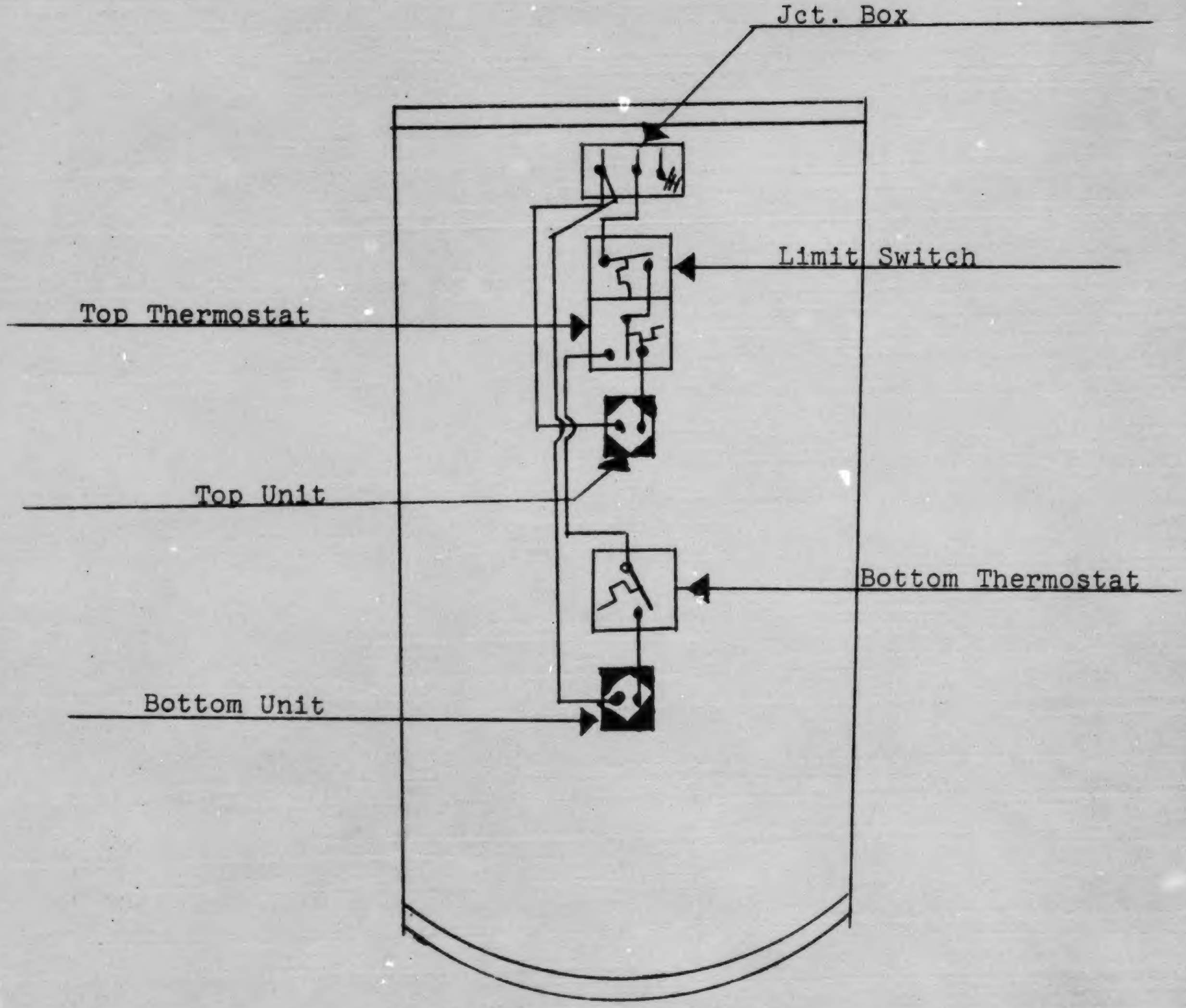
STORAGE TANKS (CON'T)
WITH DUAL HEATER ELEMENTS



STORAGE TANK
COMPONENTS



AUXILIARY HEATERS
ELECTRICAL COMPONENTS



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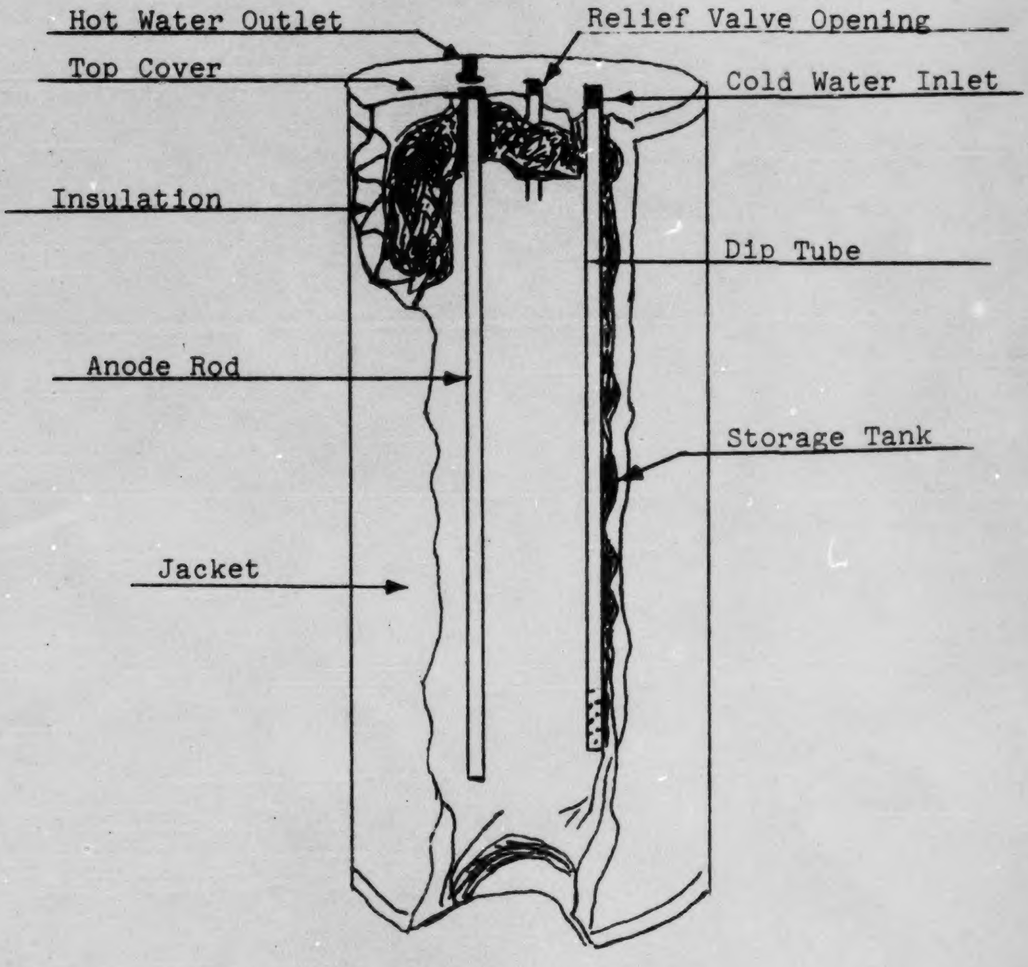
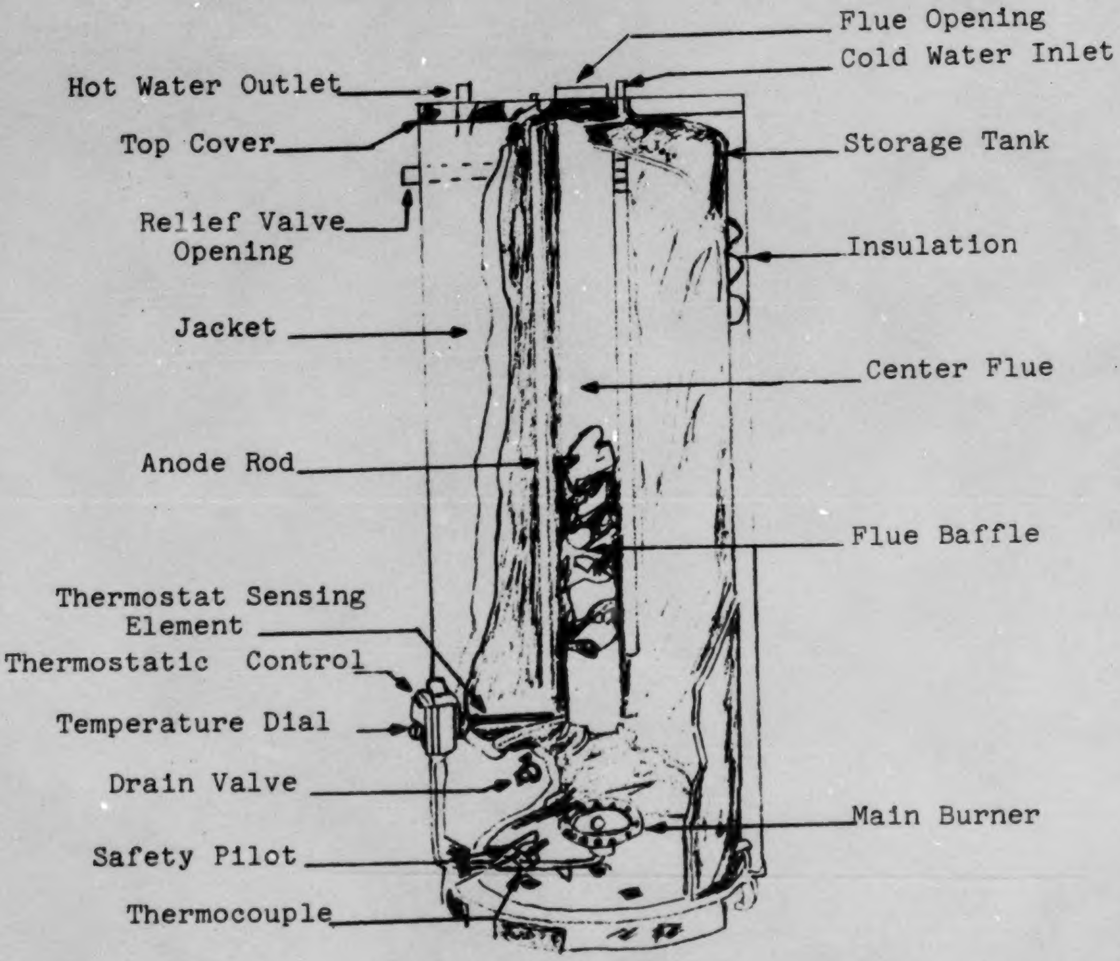
AUXILIARY SOLAR TANK
ELECTRIC



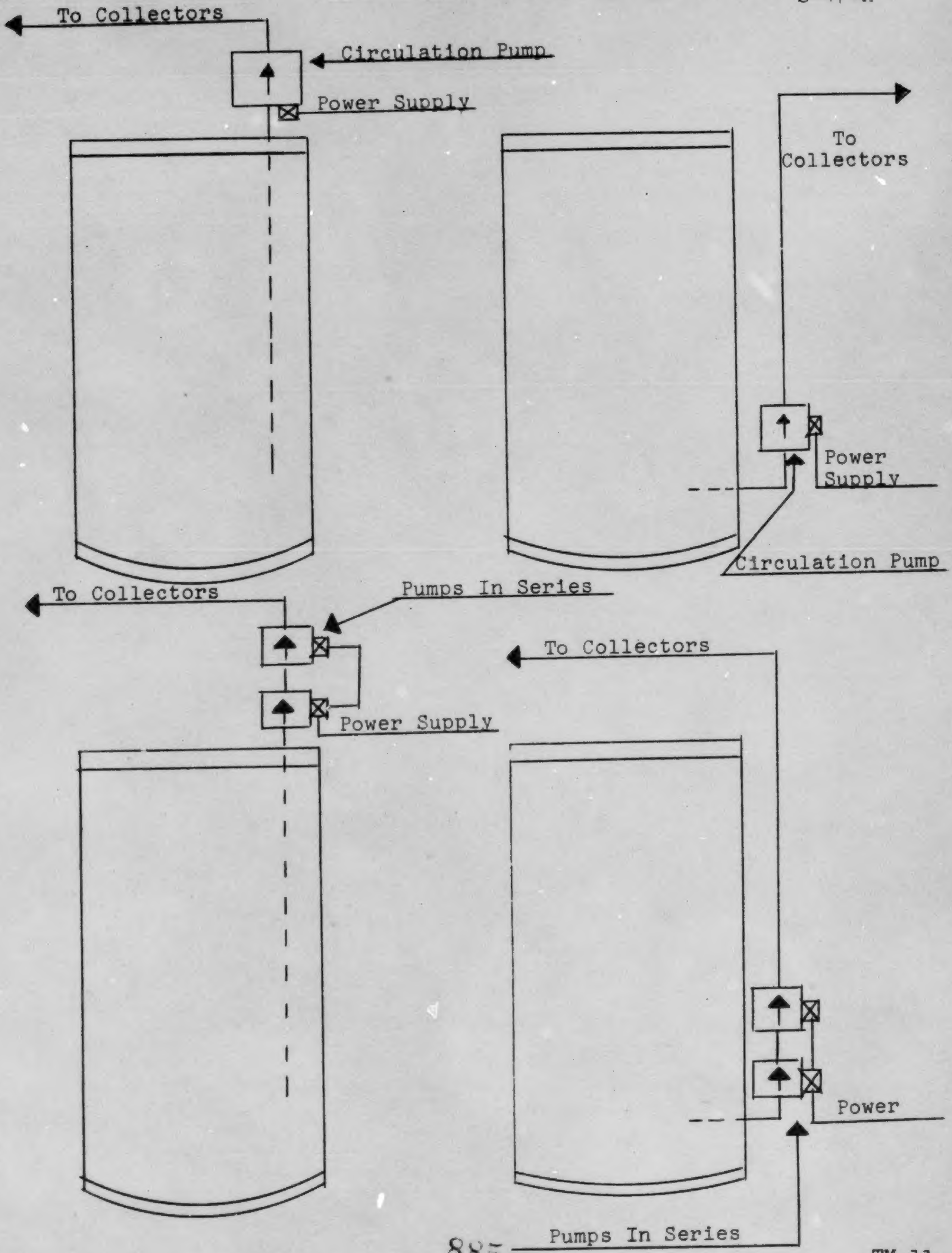
SECTIONAL VIEW OF AN AUTOMATIC
ELECTRIC STORAGE TANK WATER HEATER

GAS FIRED AUXILIARY HEATER



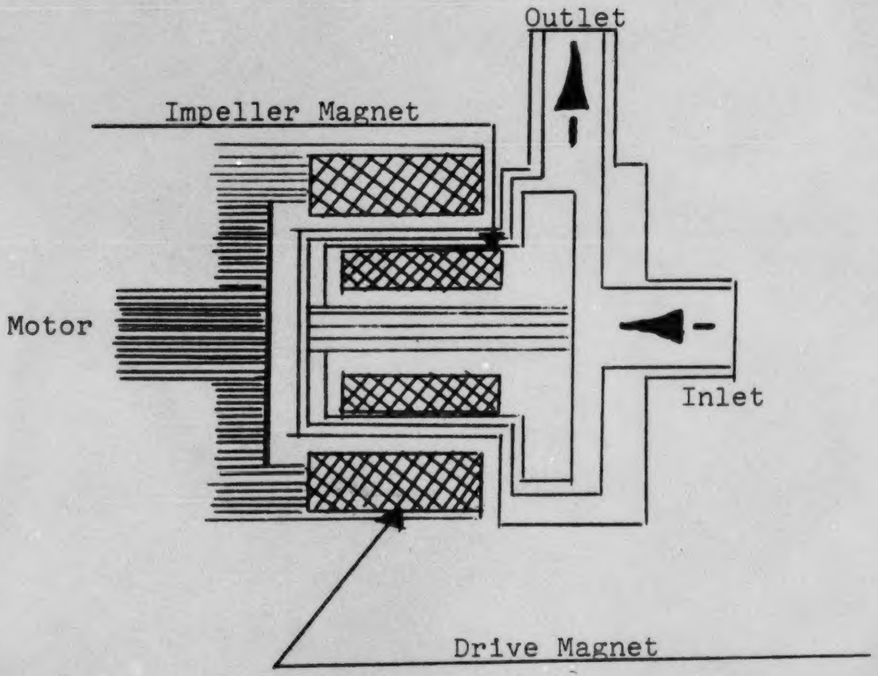
SECTIONAL VIEW OF AN
AUTOMATIC GAS STORAGE TANK WATER HEATER

CIRCULATOR PUMPS

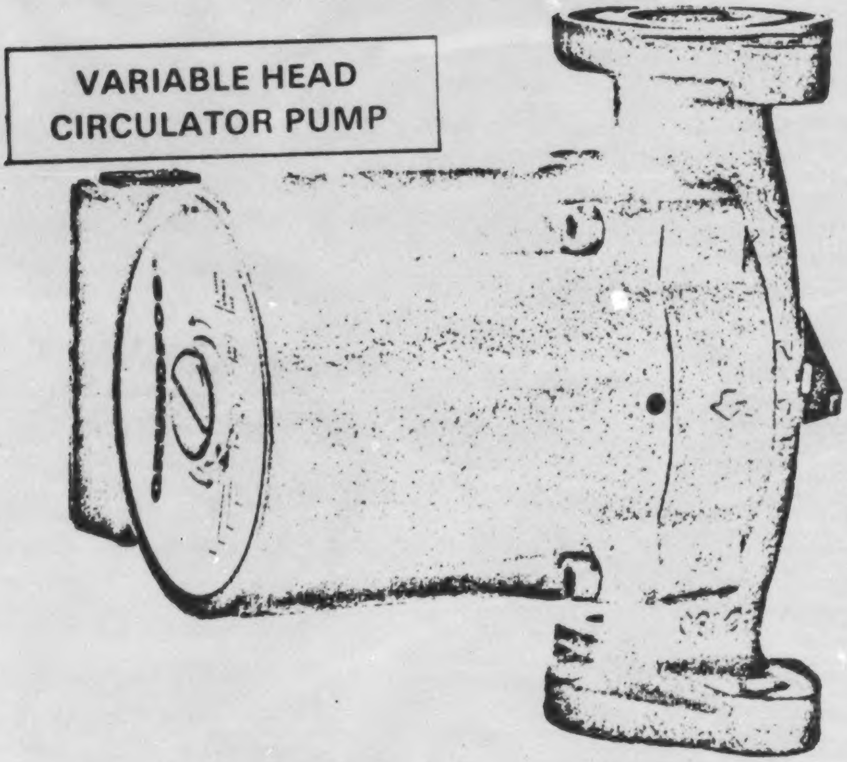


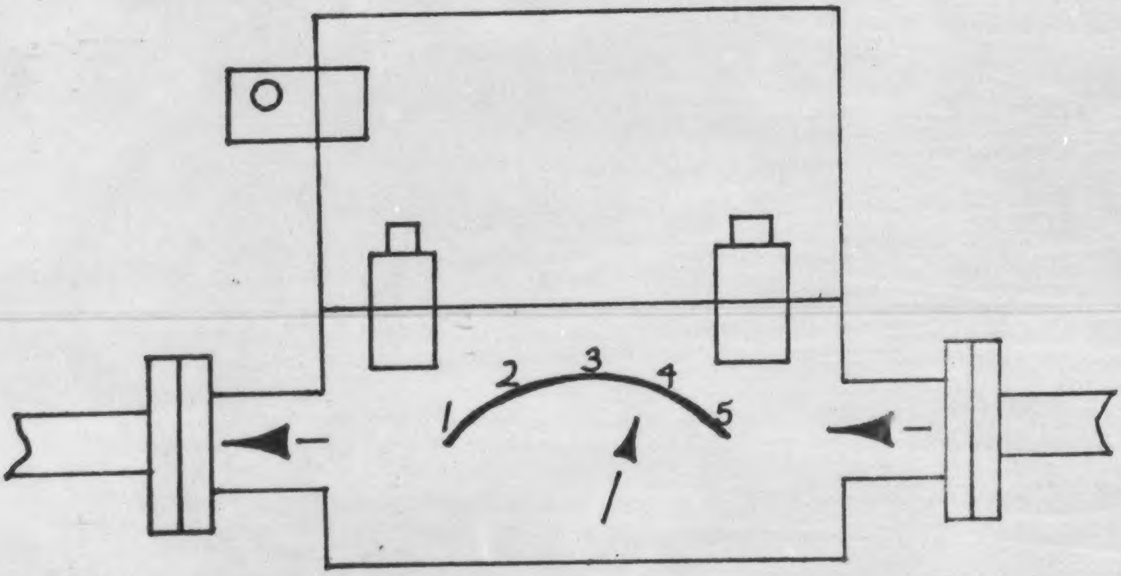
CIRCULATING PUMPS
(CONTINUED)

MAGNETIC DRIVE



Circulator Pumps (Continued)



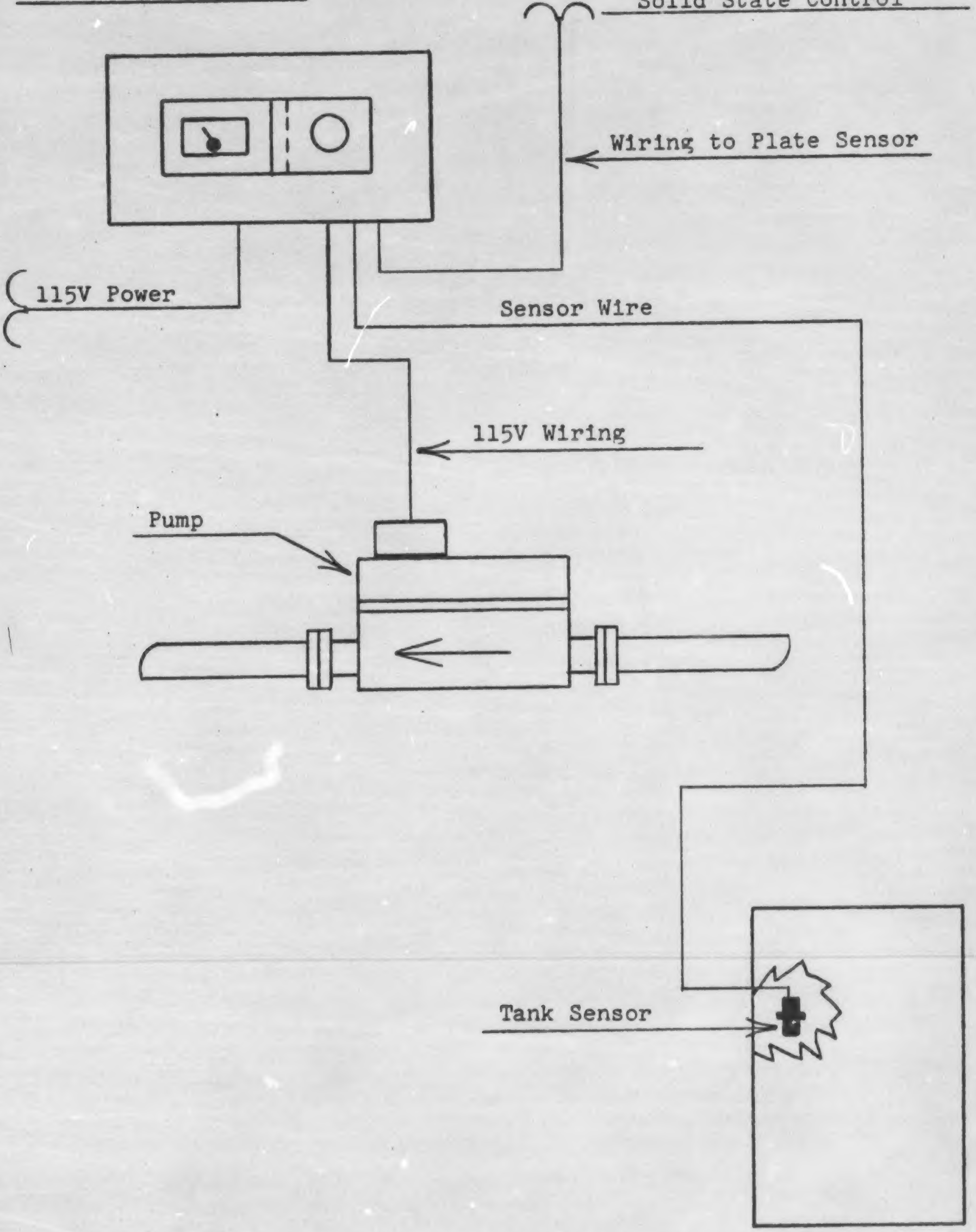


(Courtesy Grundfos Corp.)

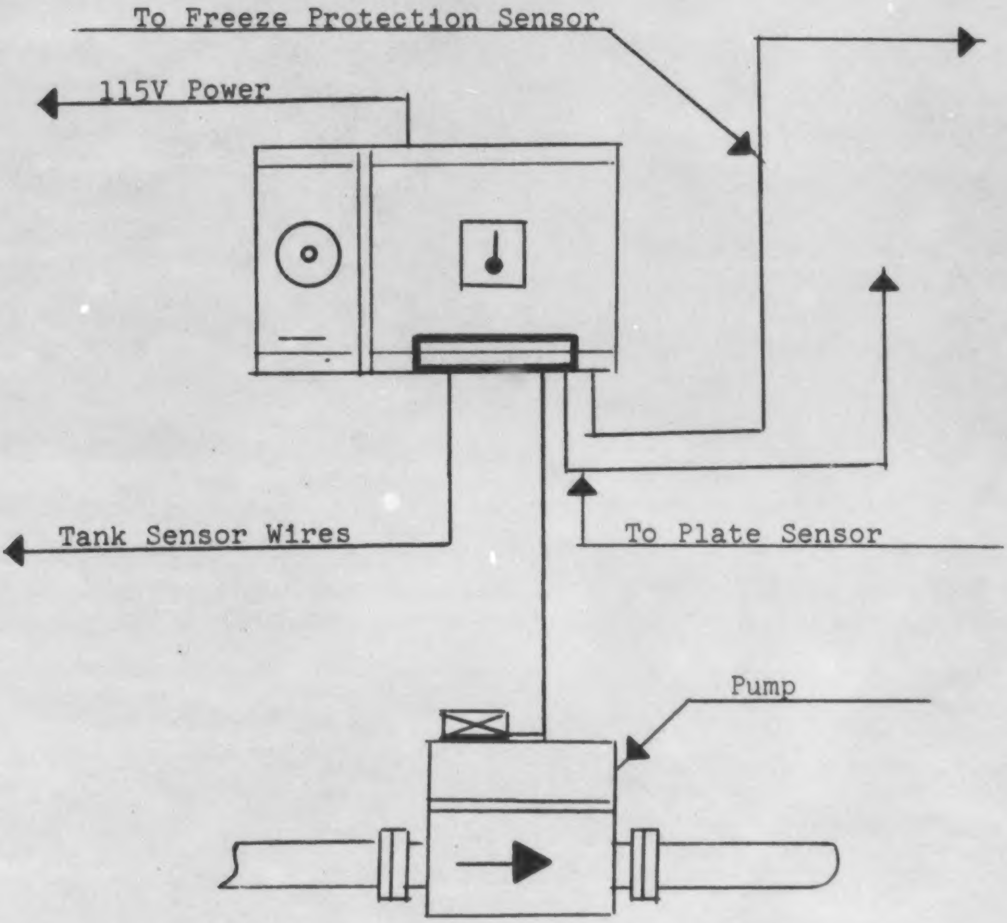
CONTROLS

Differential Temperature
Thermostat
Solid State Control

No Drain Down

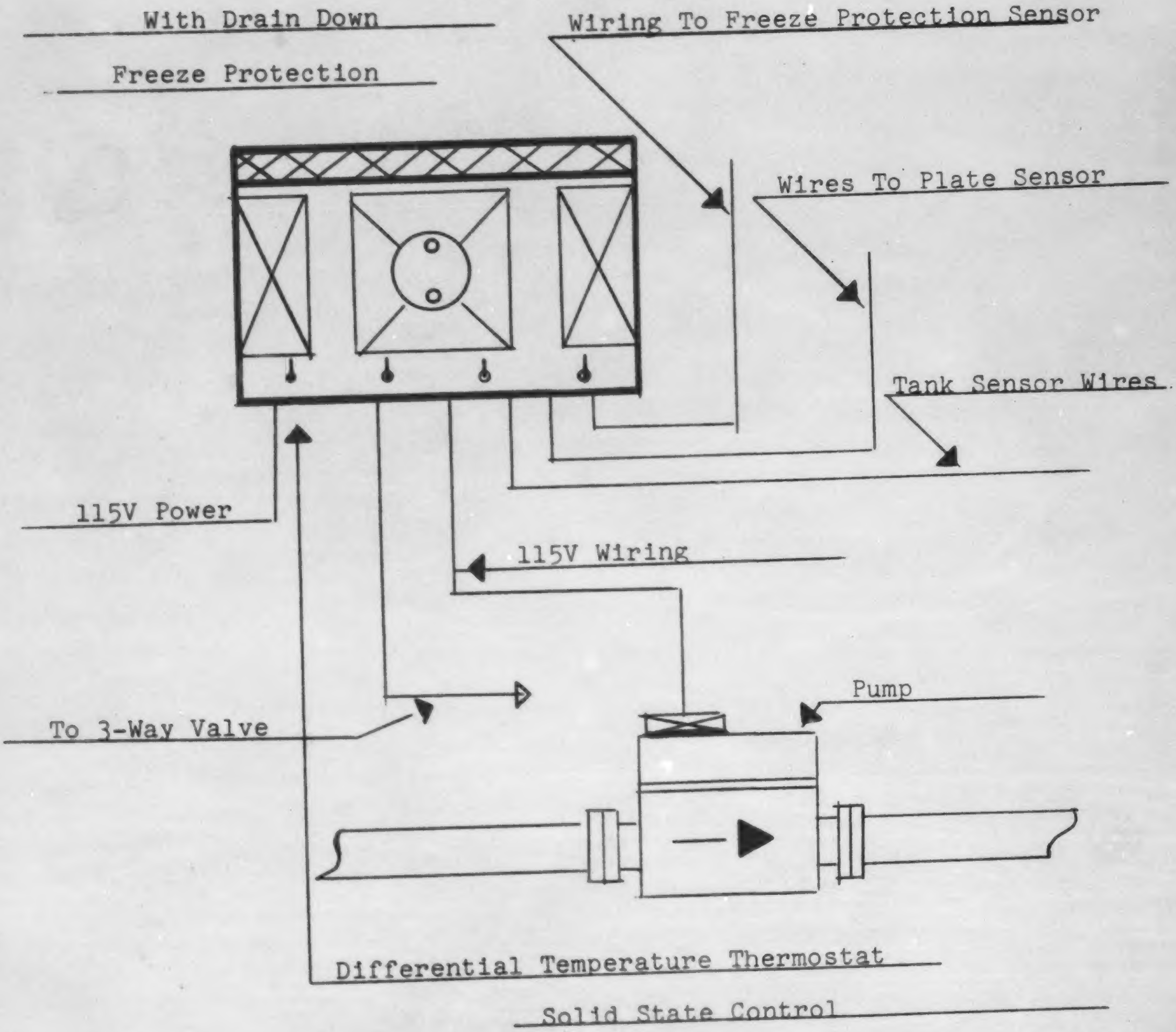


CONTROLS
(CONTINUED)

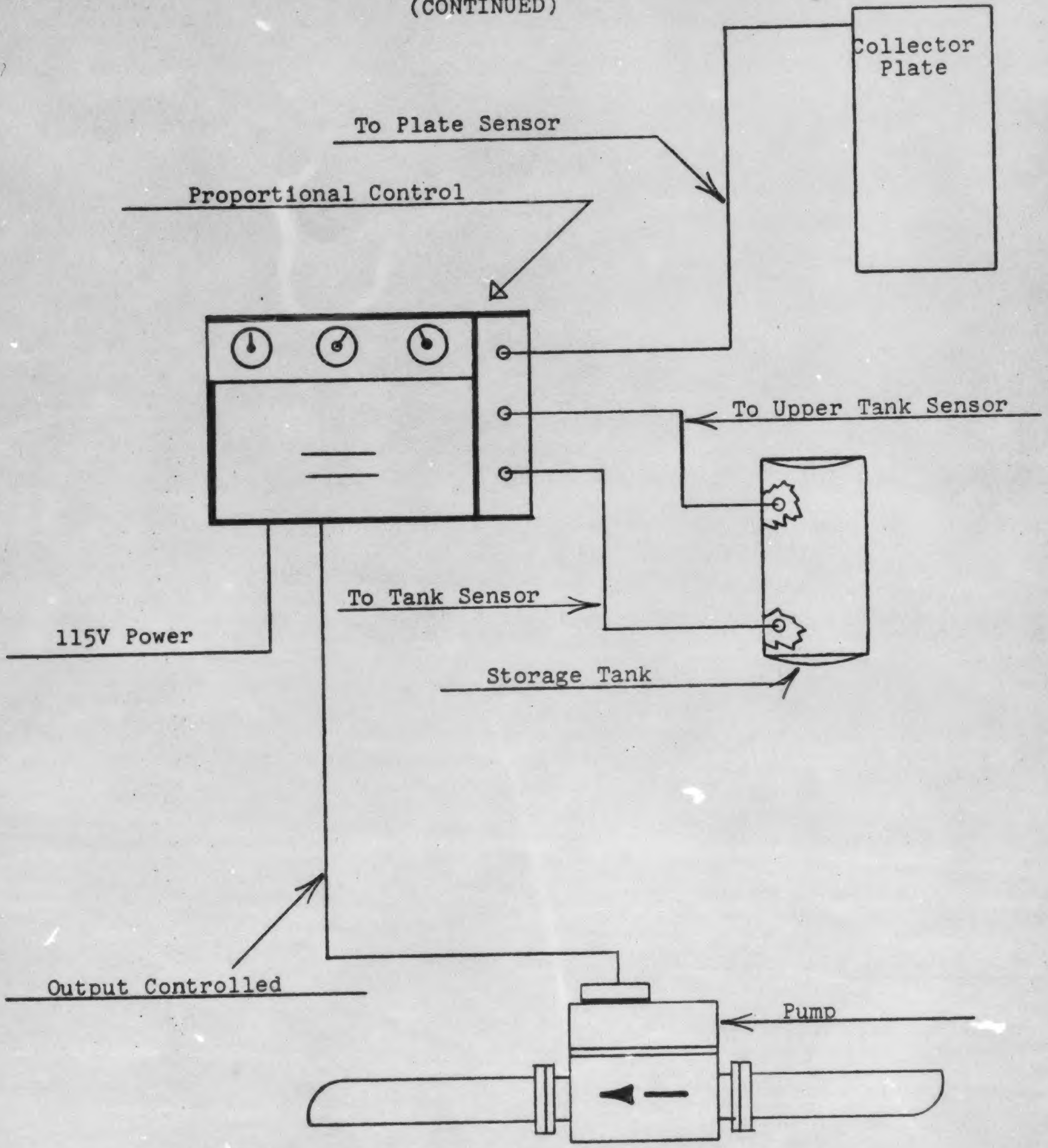


Differential Temperature Thermostat-With Recirculation For Freeze Protection

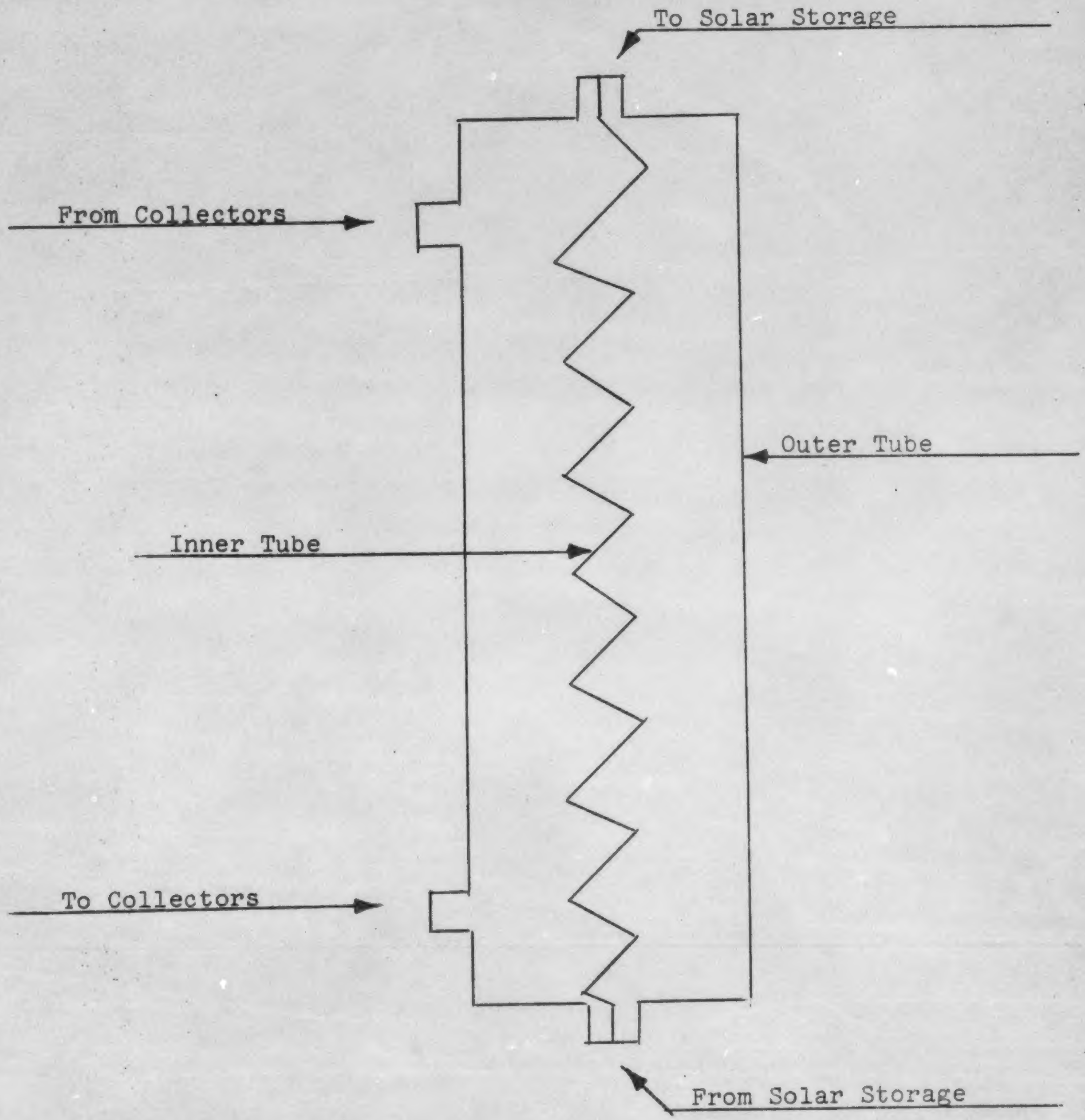
CONTROLS
(CONTINUED)



CONTROLS
(CONTINUED)

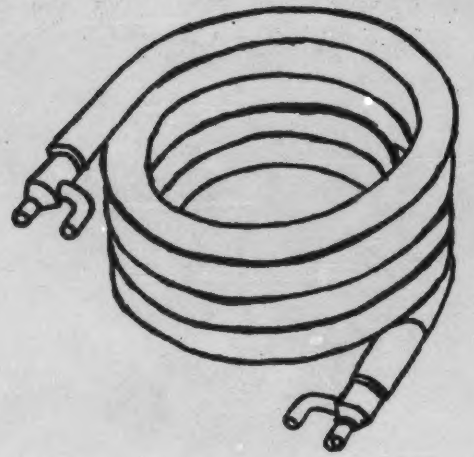


HEAT EXCHANGER
TUBE AND SHELL TYPE



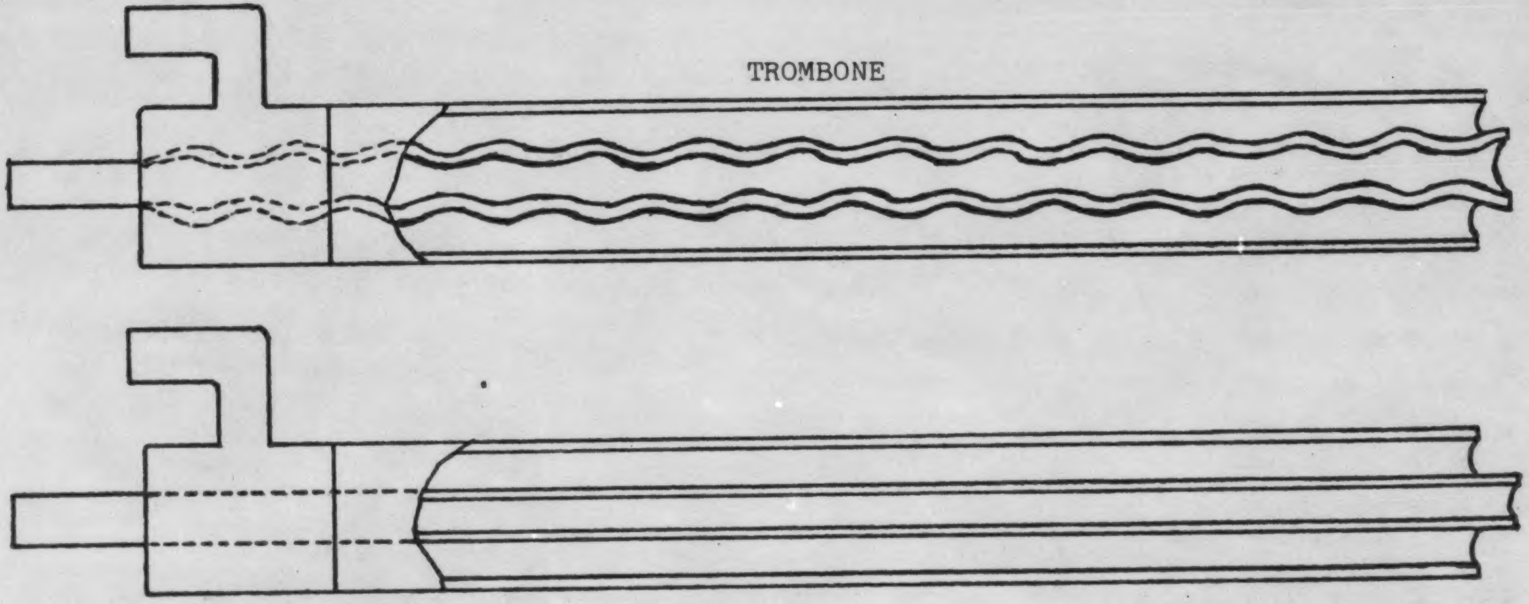
HEAT EXCHANGERS
(CONTINUED)

CO-AXIAL COILS



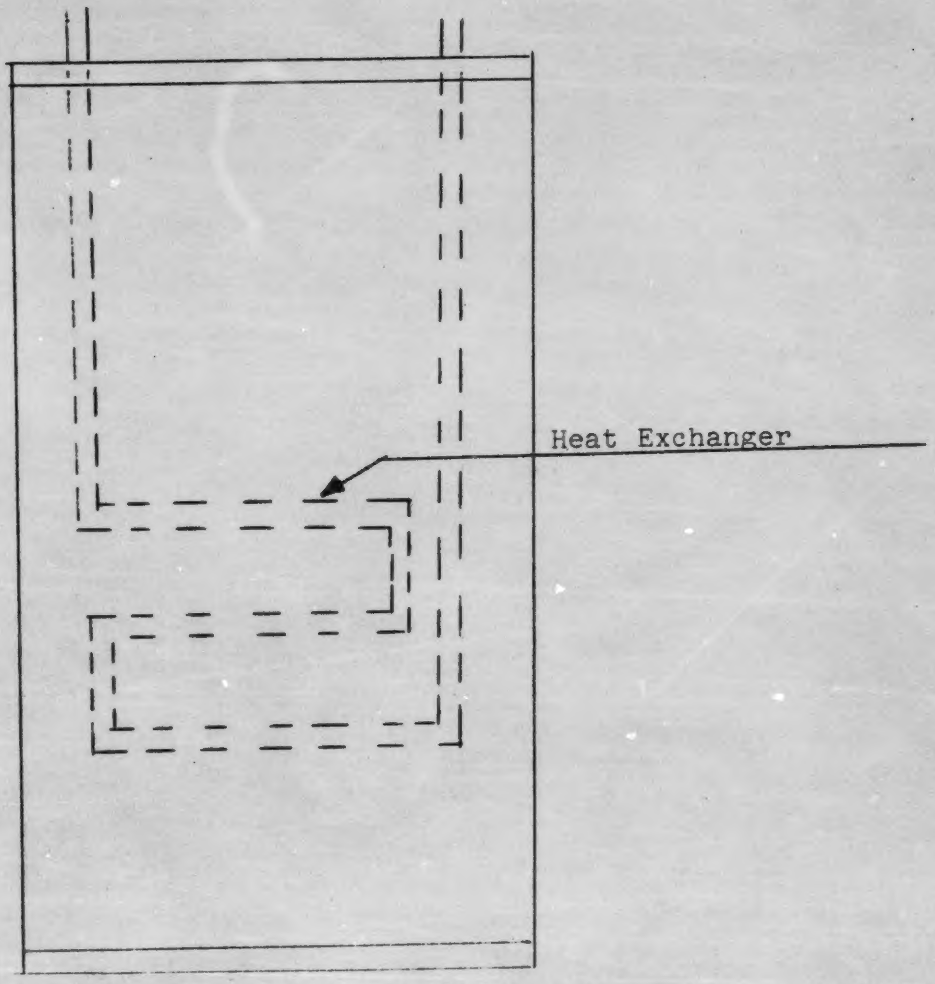
HELICAL

TROMBONE

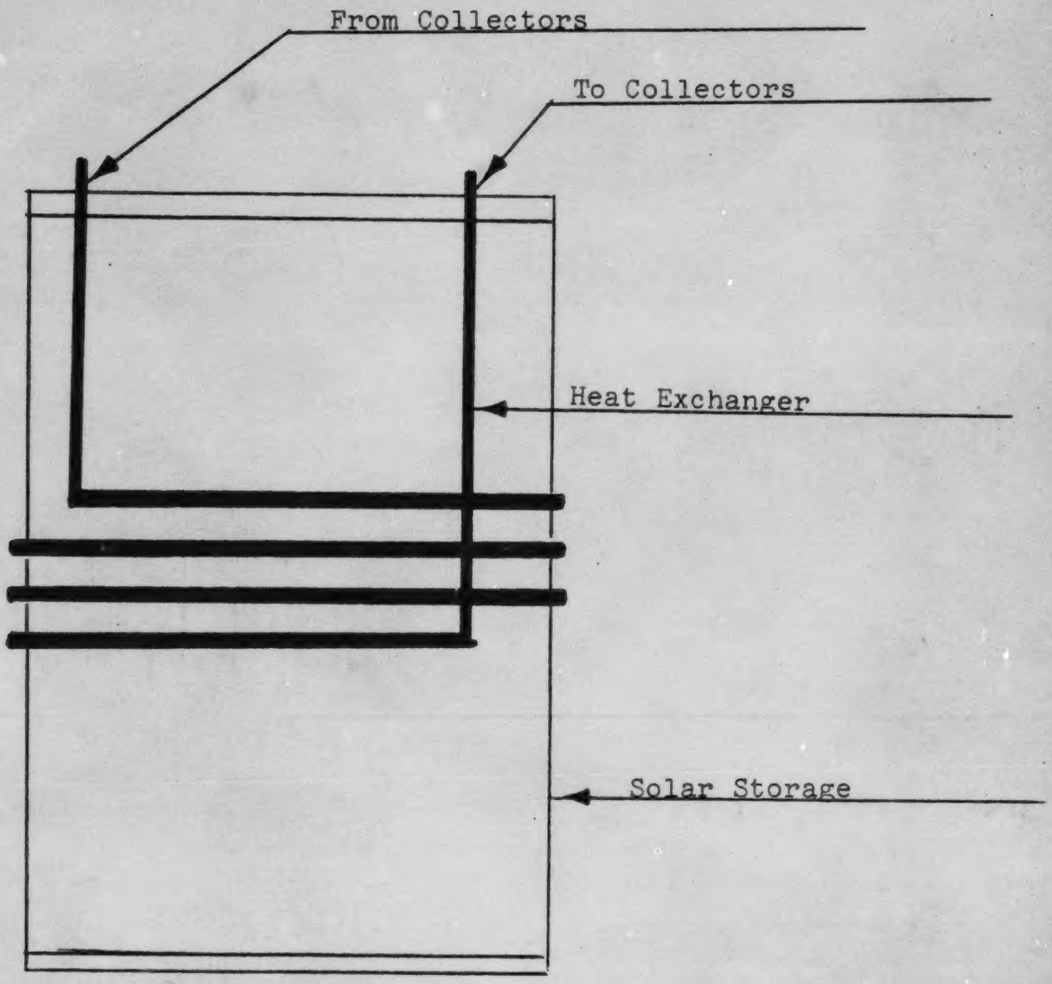


(Courtesy Precision Bending Mfg. Inc.)

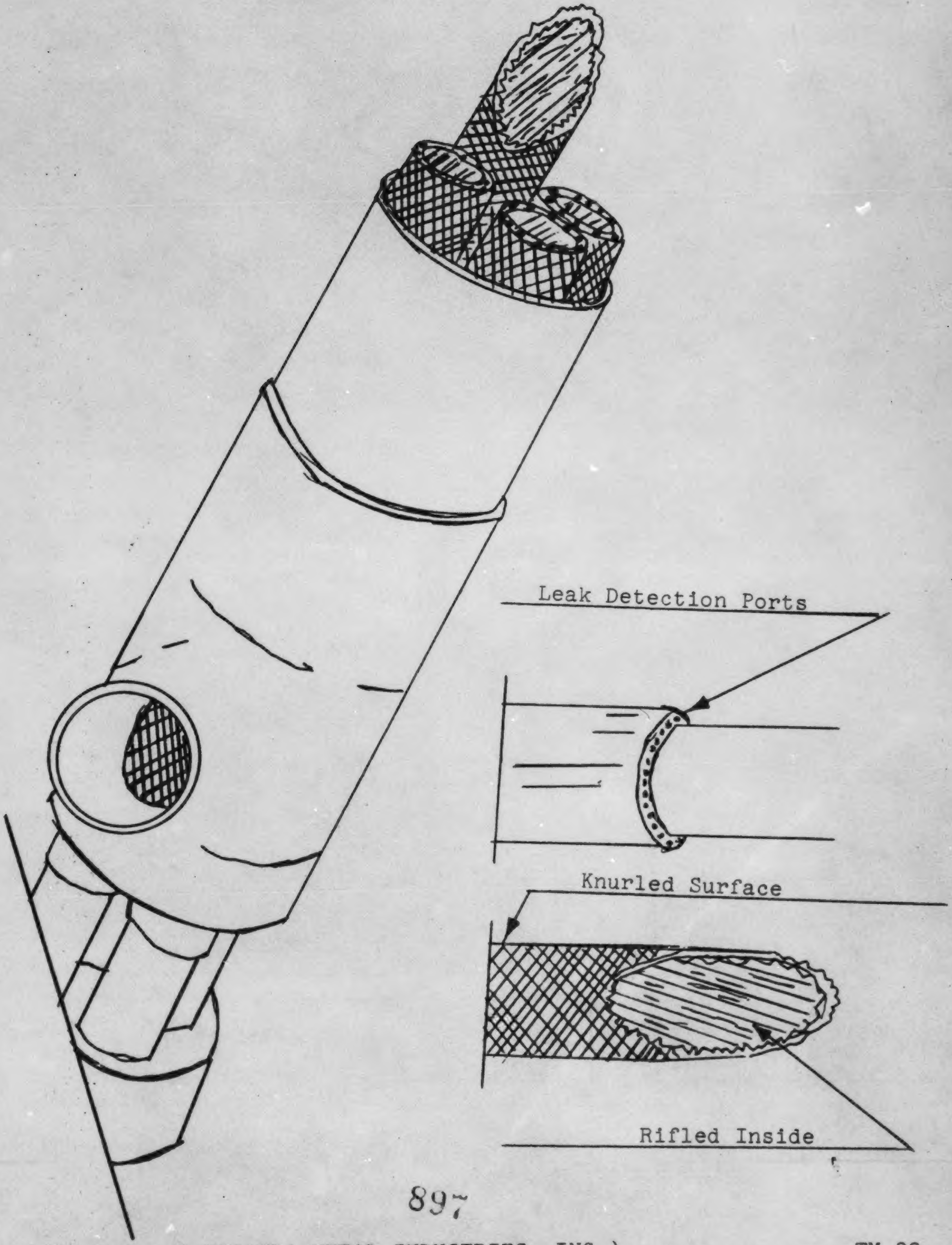
HEAT EXCHANGERS (CON'T.)
EMERSION TYPE



HEAT EXCHANGER (CON'T.)
EXTERNAL WRAP AROUND TYPE



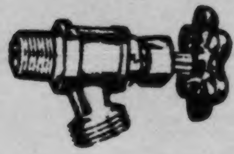
HEAT EXCHANGERS
(CONTINUED)
DOUBLE AUGMENTED TYPE



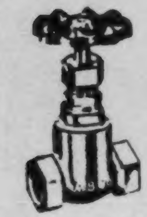
(Courtesy of NORANDA METAL INDUSTRIES, INC.)

VALVES

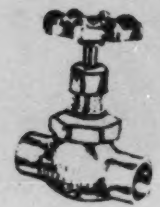
boiler drain



gate

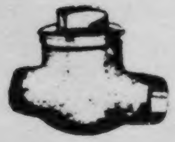


globe

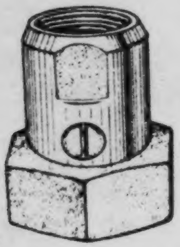


ISOLATION VALVES

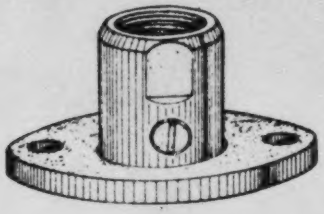
SWING CHECK



Union Isolation Valve



Flange Isolation Valve



VALVES
(CONTINUED)

VACUUM RELIEF VALVE

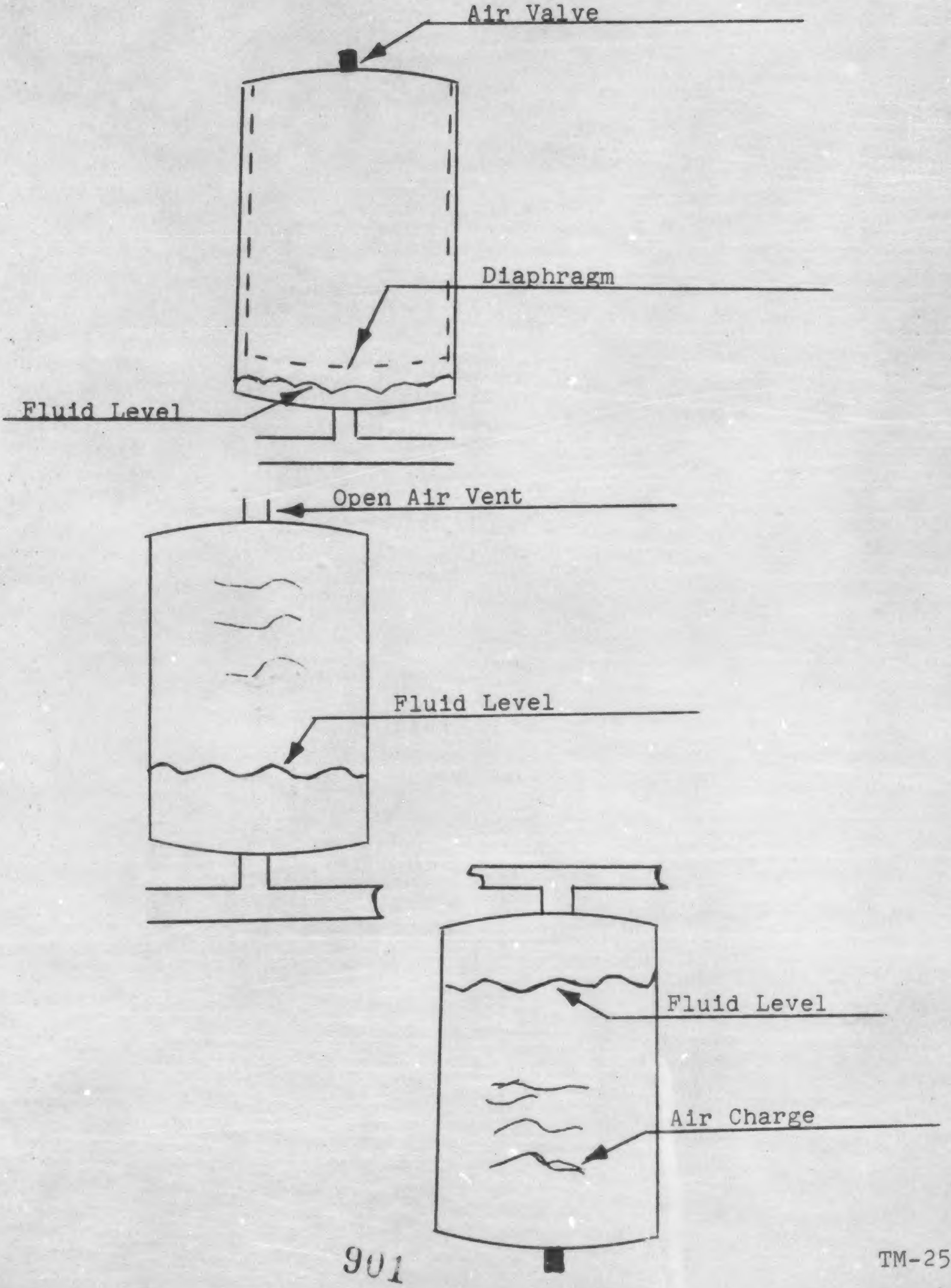
AUTOMATIC AIR VENT

PRESSURE RELIEF VALVE

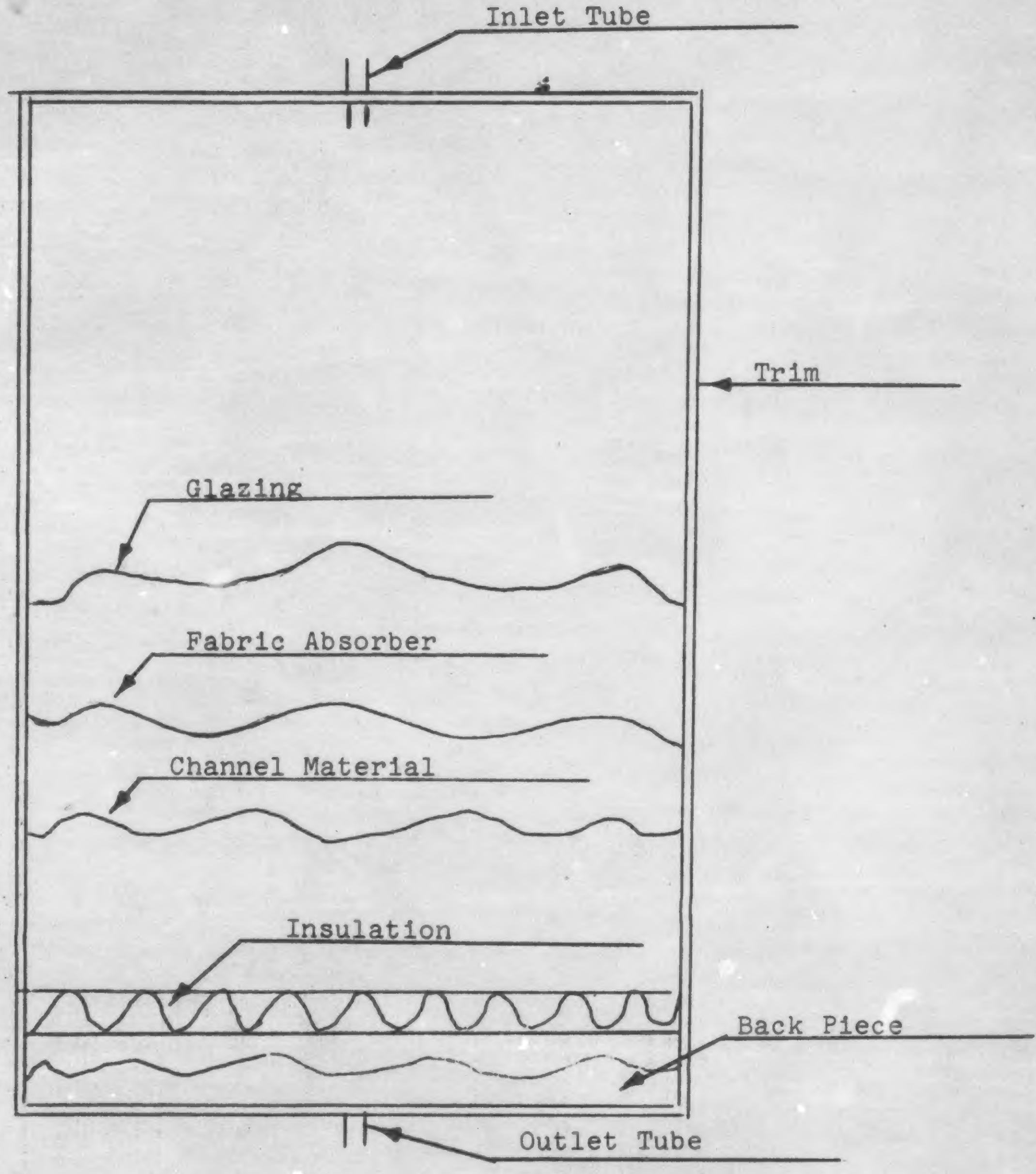
TEMPERATURE AND
PRESSURE RELIEF VALVE

MIXING VALVE

EXPANSION TANKS

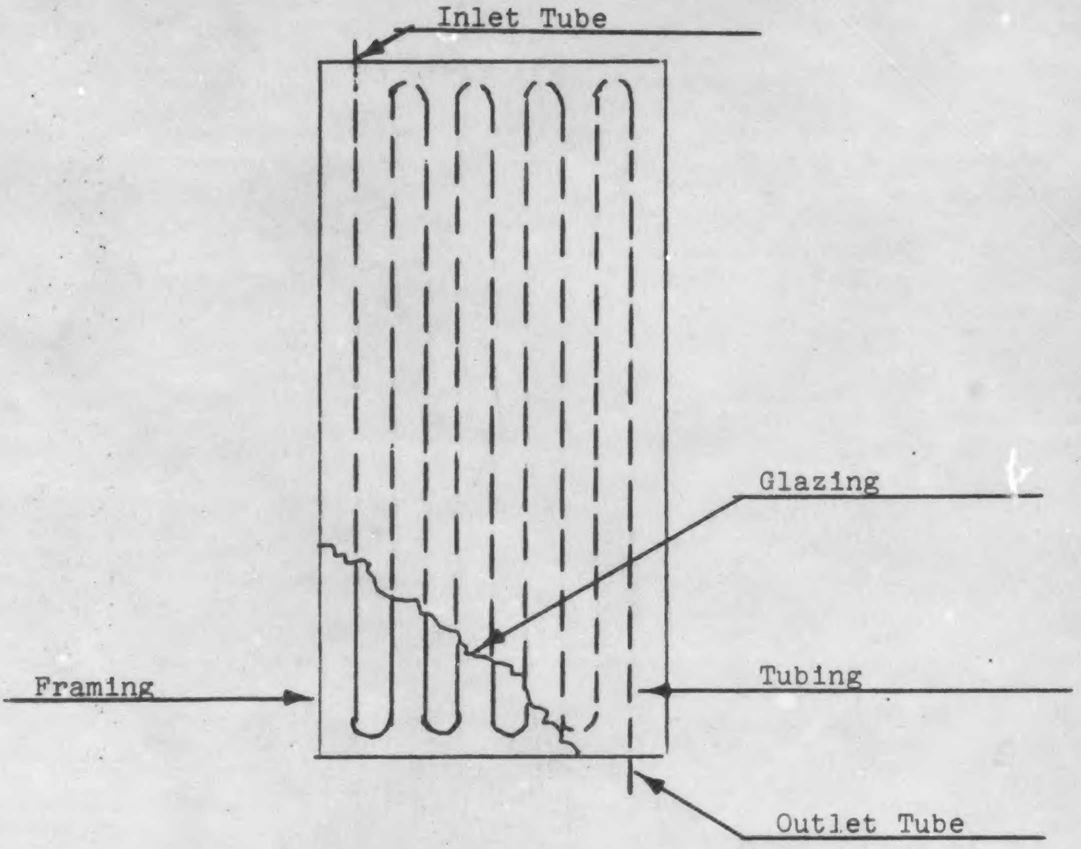


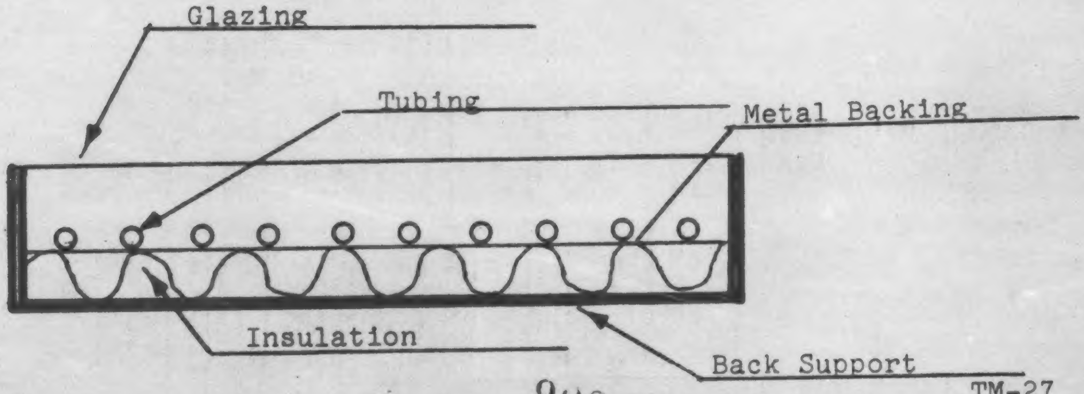
FLAT PLATE COLLECTORS
TRICKLE TYPE



(Courtesy of ENERTEK ENERGY ENGINEERING, INC.)

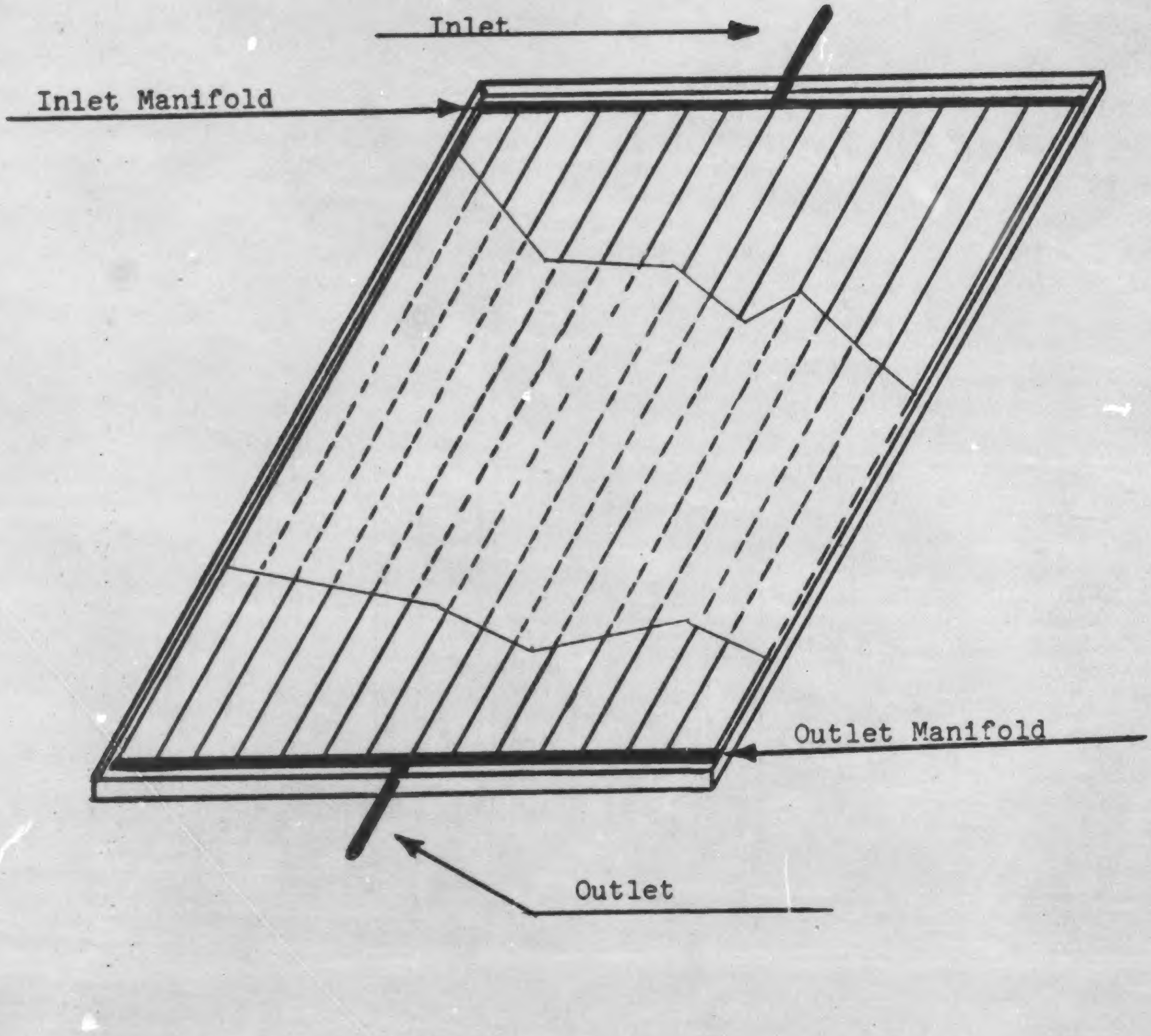
FLAT PLATE COLLECTORS
(CONTINUED)
SERPENTINE TYPE





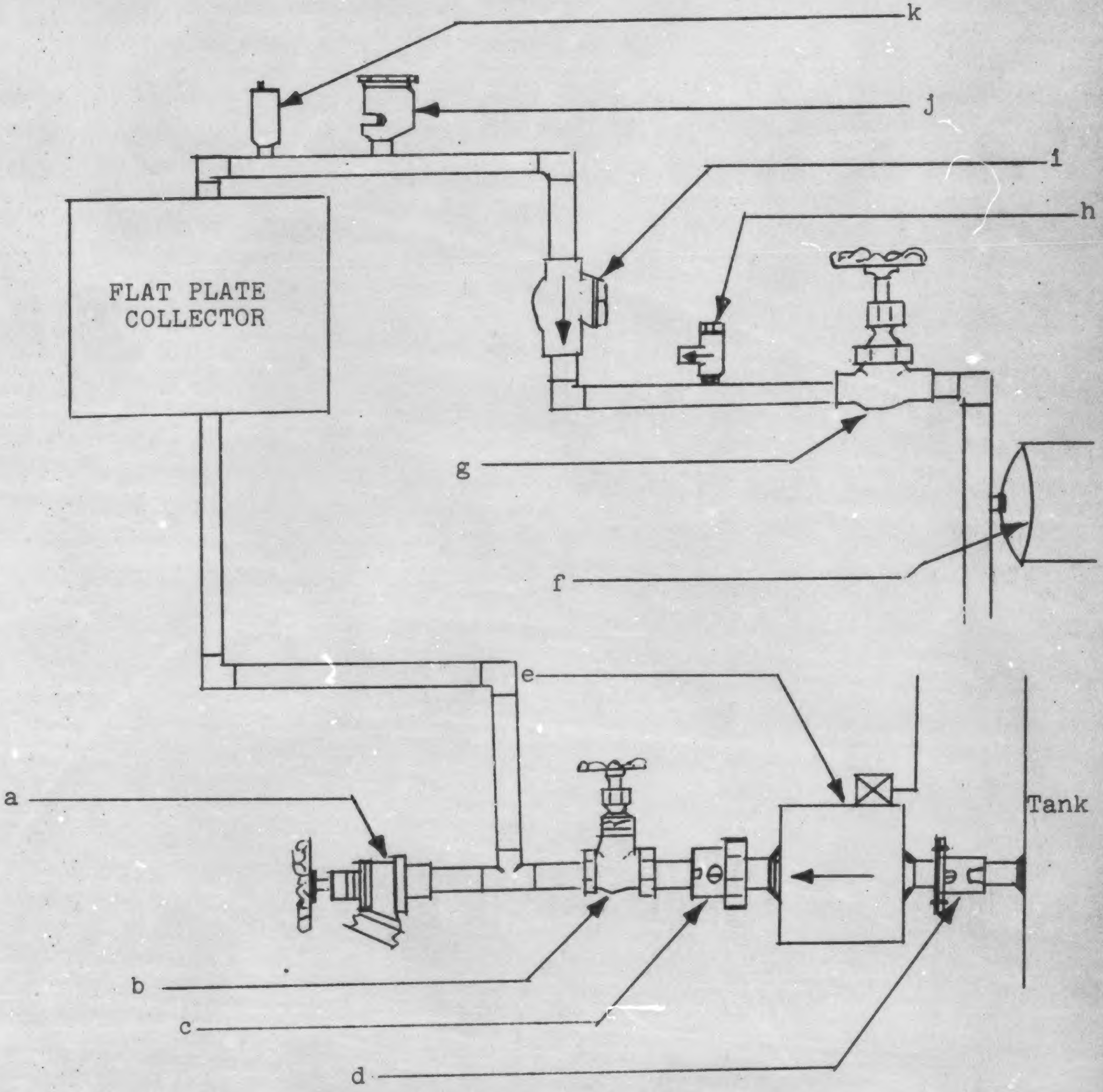
FLAT PLATE COLLECTORS

(CONTINUED)
PARALLEL TUBING TYPE



SYSTEM COMPONENTS
UNIT I

ASSIGNMENT #1--IDENTIFY MECHANICAL COMPONENTS IN A SOLAR HOTWATER SYSTEM DIAGRAM

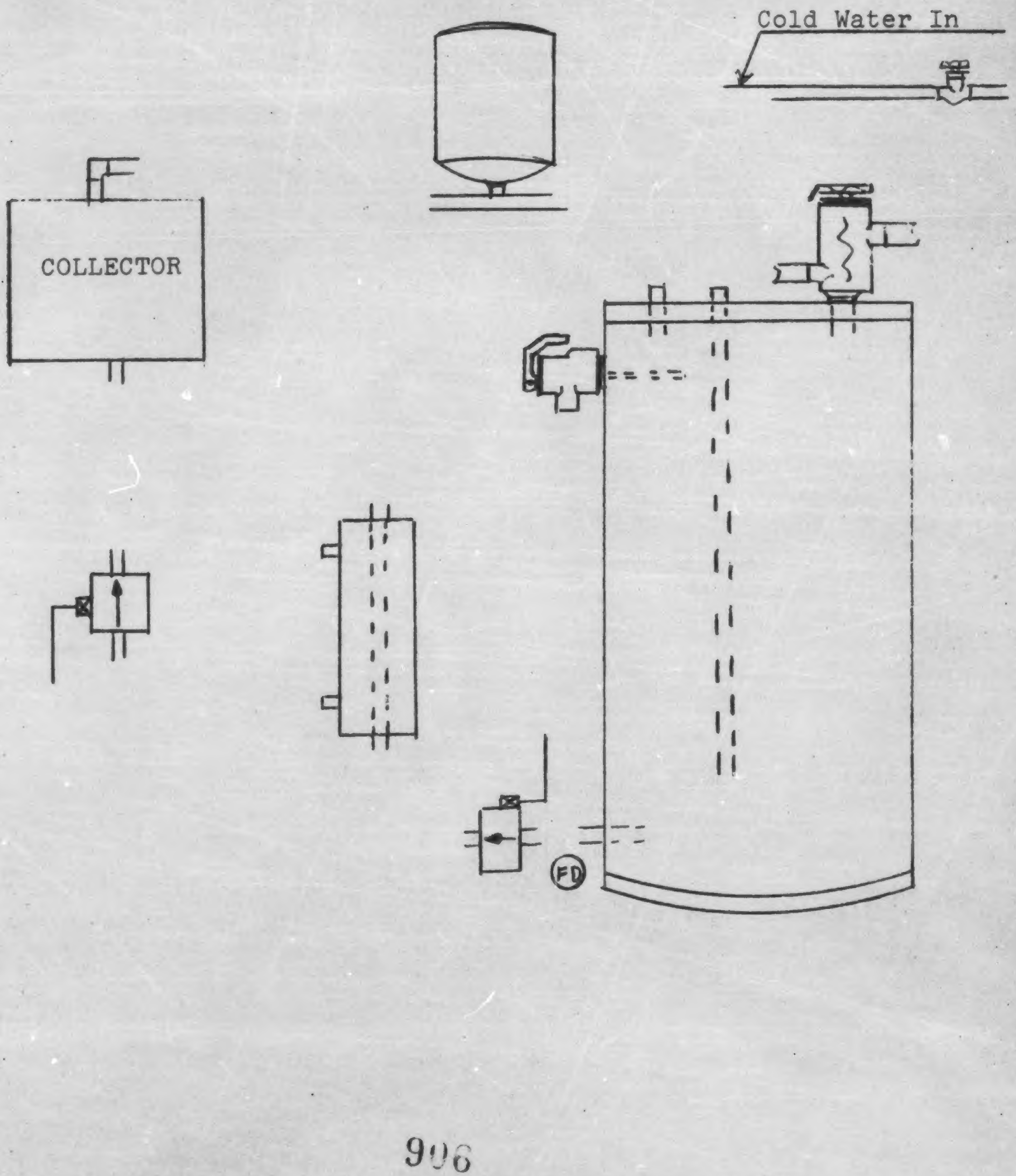


S-85-H

SYSTEM COMPONENTS
UNIT I

ASSIGNMENT #2--COMPLETE THE PIPING IN AN INCOMPLETE DIAGRAM OF A SOLAR HOTWATER SYSTEM

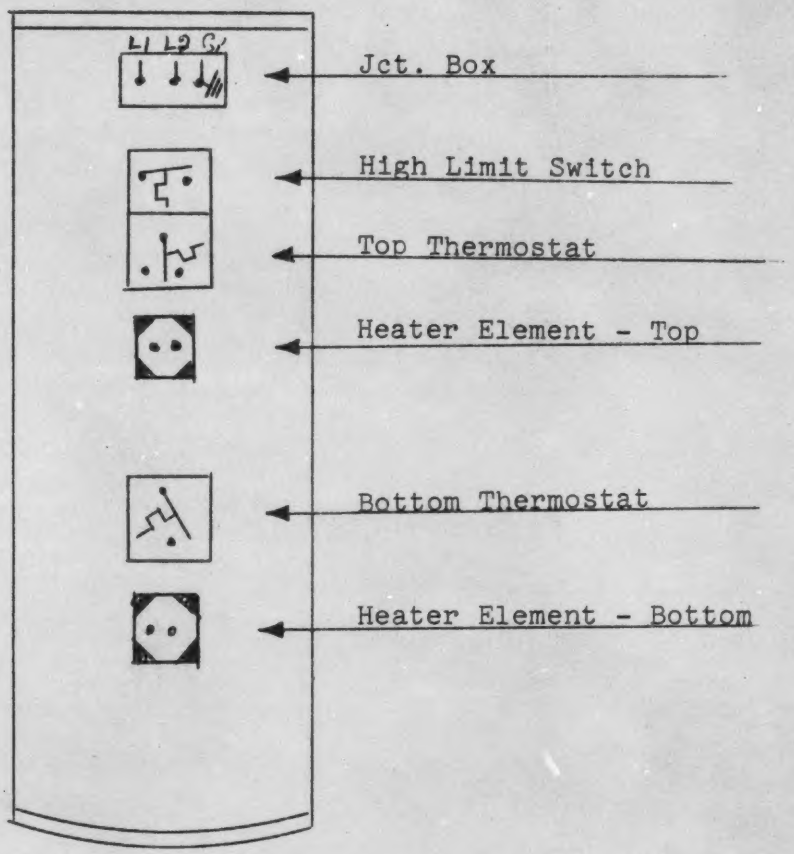
(NOTE: The pipe must be drawn with double lines.)



SYSTEM COMPONENTS
UNIT I

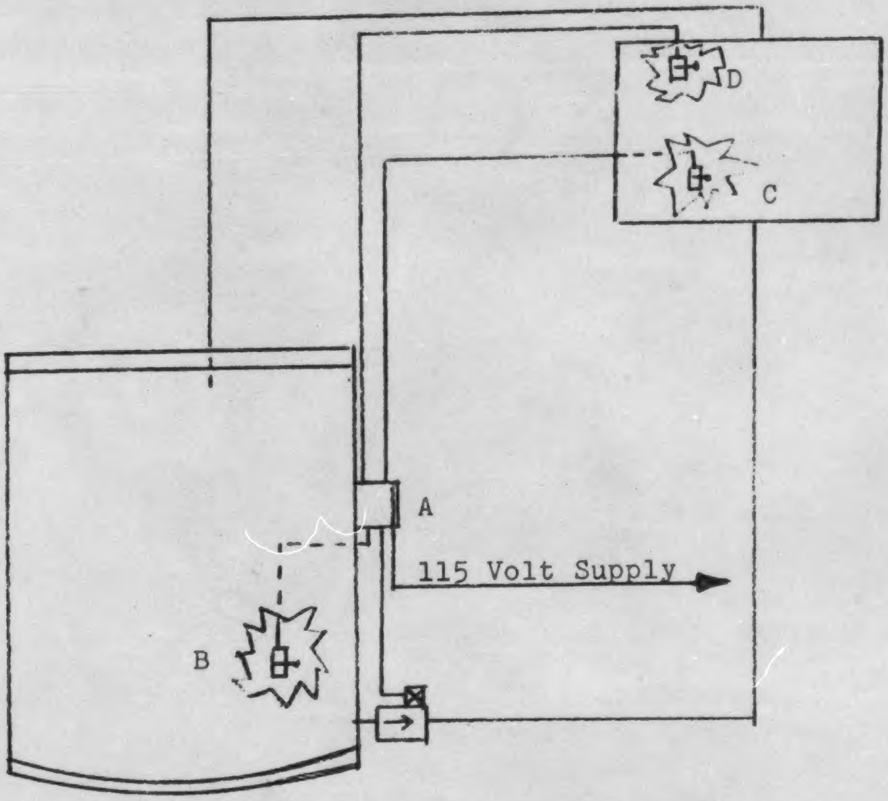
ASSIGNMENT #3--COMPLETE A WIRING DIAGRAM FOR A DUAL ELEMENT AUXILIARY HEATER

Instructions: Complete the diagram for 230 volt operation with the bottom unit receiving power only when the top thermostat is satisfied.



SYSTEM COMPONENTS
UNIT I

ASSIGNMENT #4--IDENTIFY THE CONTROL COMPONENTS FOR A SOLAR HOTWATER SYSTEM



A. ______________________

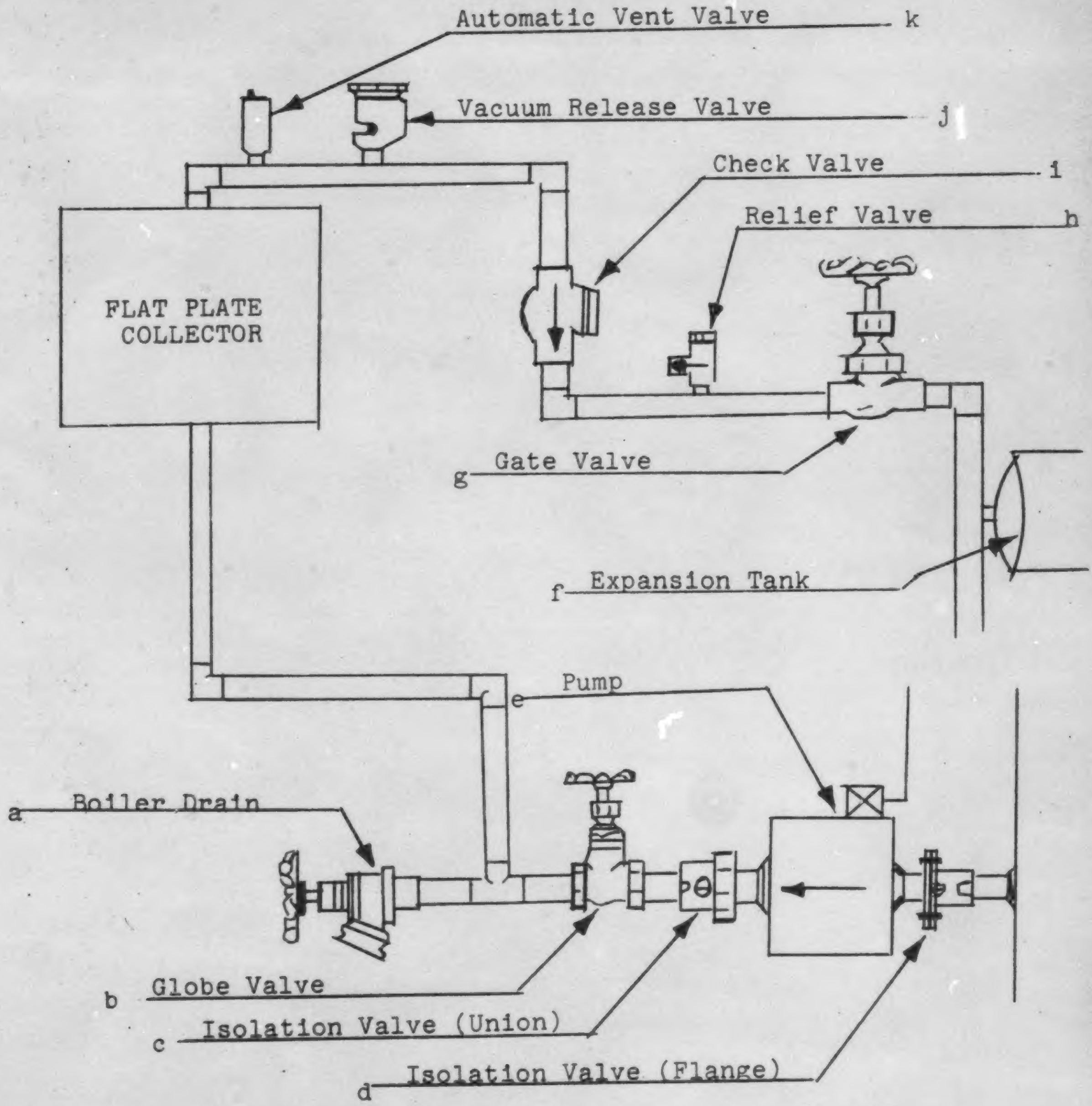
B. ______________________

C. ______________________

D. ______________________

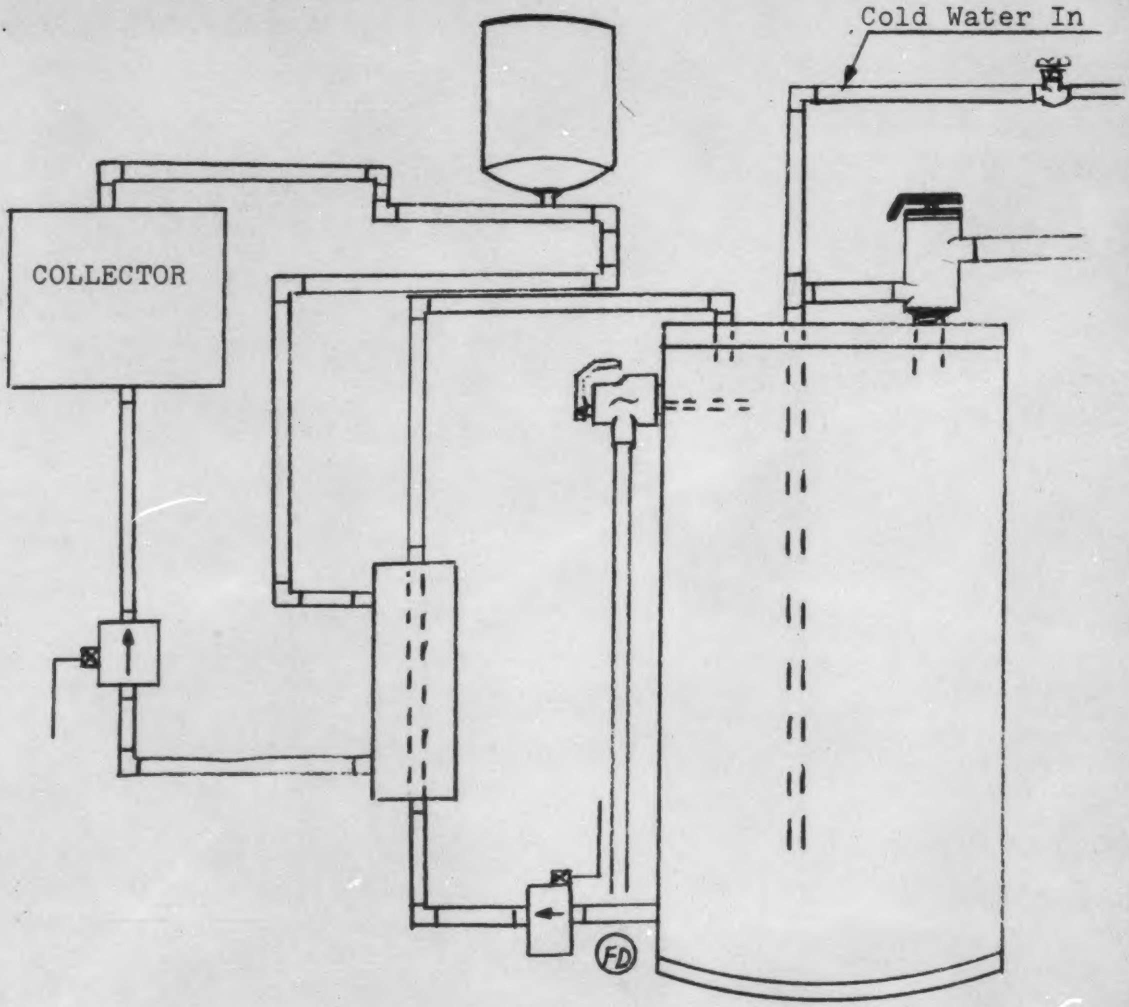
SYSTEM COMPONENTS
UNIT I

ANSWERS TO ASSIGNMENT SHEET #1



SYSTEM COMPONENTS
UNIT I

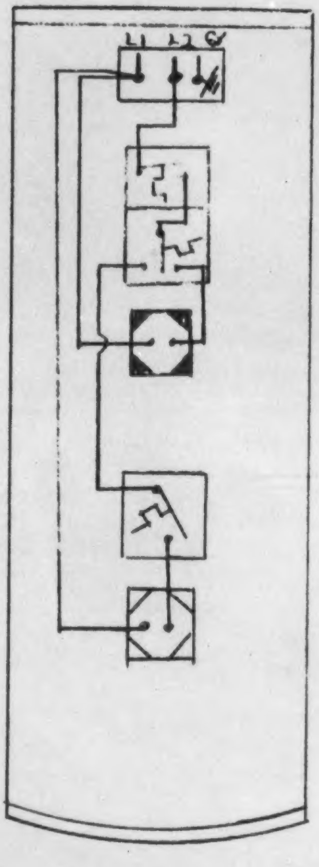
ANSWERS TO ASSIGNMENT SHEET #2



S-95-H

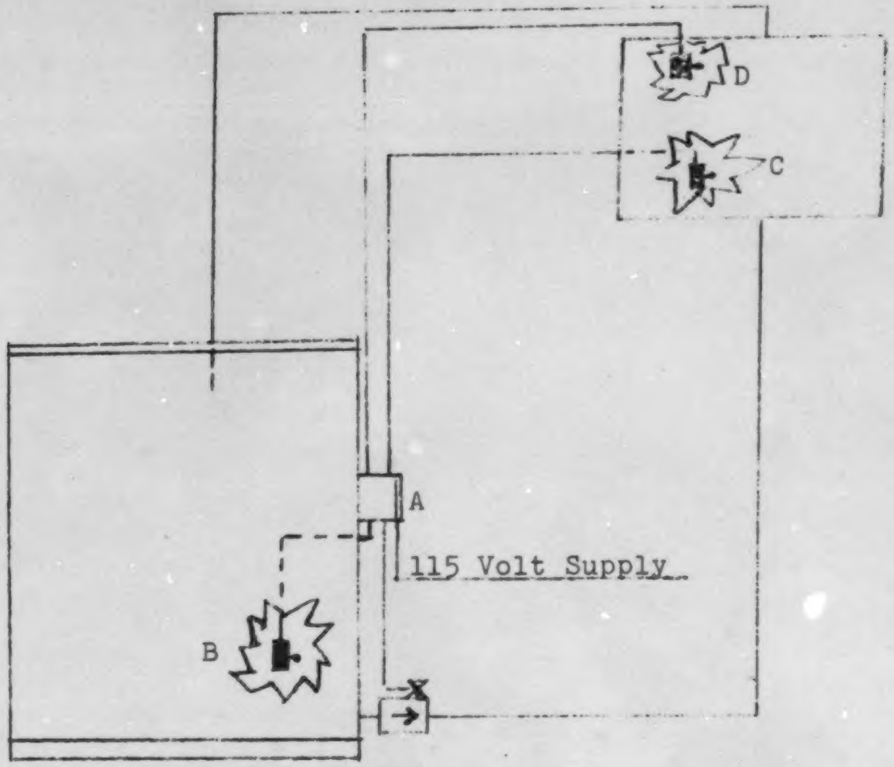
SYSTEM COMPONENTS
UNIT I

ANSWERS TO ASSIGNMENT SHEET #3



SYSTEM COMPONENTS
UNIT I

ANSWERS TO ASSIGNMENT SHEET #4



A. Differential-Temperature control/with freeze protection

B. Tank sensor

C. Freeze protection sensor

D. Plate (atmosphere) sensor

S-99.-H

SYSTEM COMPONENTS
UNIT I

NAME______________________________

TEST

1. Match the terms on the right to their correct definition.

_____a. A sensing device that changes its electrical resistance with temperature change

_____b. Piping and components between the storage tank and remote mounted heat exchanger

_____c. Provisions for storing the collected solar energy until it is needed

_____d. Energy delivered to the earth by the sun

_____e. An electrical device that controls operation of the solar system

_____f. Rate at which solar energy reaches the outer limits of the earth's atmosphere. (Rated at 429 BTU's per square foot per hour)

_____g. A thermister device that is used with solar controls

_____h. Water free from harmful impurities, suited for human consumption

_____i. Liquid used to transport collected energy from one point to another in a collector loop

_____j. A device that permits the transfer of thermal energy from one medium to another

1. Absorber
2. Auxiliary heater
3. Circulator pump
4. Collector loop
5. Component
6. Direct radiation
7. Diffused radiation
8. Expansion tank
9. Flat plate collector
10. Heater element
11. Solar control
12. Solar storage
13. Storage loop
14. Thermister
15. Heat exchanger
16. Heat transfer fluid
17. Potable water
18. Sensor

_____k. Radiation that passes directly to the earth's surface

_____l. Pump used to circulate heat transfer fluids in collector and storage loops

_____m. A coated surface that absorbs the solar radiation and converts it to heat energy

_____n. A resistance heater unit installed in the solar or auxiliary storage tank to provide a source of electric heat energy

_____o. An individual product that forms part of a more complex product

_____p. A separate storage tank with heat energy source other than solar. (Used as a back-up for the solar system)

_____q. That part of a solar system that contains the collectors, pumps, valves, etc., to circulate the transfer fluid

_____r. Radiation that is diffused or scattered by atmospheric particles, clouds, and pollution

_____s. A small tank installed in a collector loop to prevent excessive pressure build-up of the heat transfer fluid as it expands in a closed loop

_____t. A device that converts the sun's radiation into heat energy on a flat surface

19. Solar constant

20. Solar radiation

2. Describe four types of solar storage tanks.

a. ____

____

b. ____

____

c. ____

____

d. ____

____

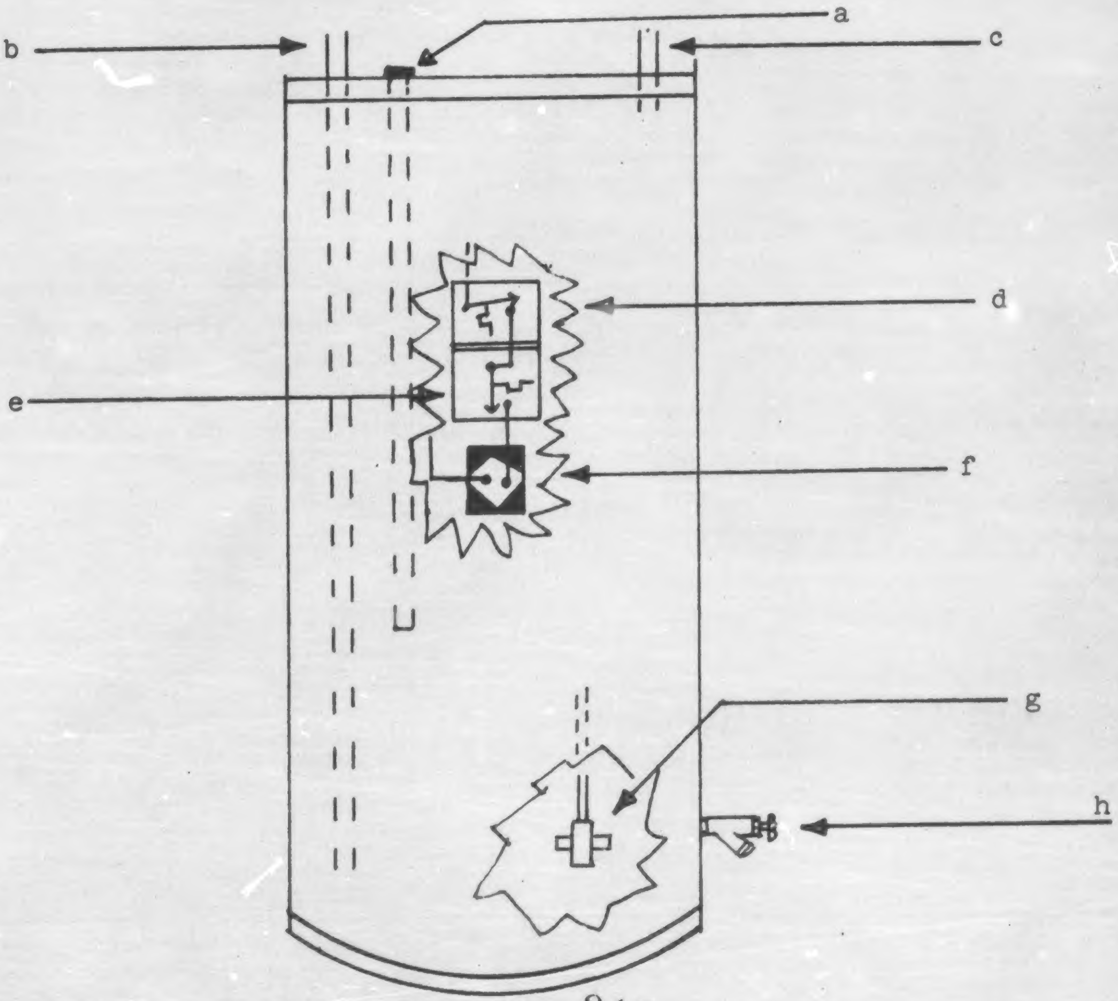
3. List three (3) standard sizes of storage tanks.

a. __________________________

b. __________________________

c. __________________________

4. Identify common components of glass and stone lined tanks.



5. Match electrical and mechanical components of electric auxiliary heaters on the left to their correct description.

_____a. Junction box

_____b. High limit switch

_____c. Bottom unit

_____d. Top thermostat

_____e. Top element

_____f. Bottom thermostat

_____g. Top cover

_____h. Dip tube

_____i. Relief valve opening

_____j. Insulation

_____k. Hot water outlet

_____l. Cold water inlet

_____m. Anode rod

_____n. Storage tank

_____o. Jacket

1. Controls on/off cycle of bottom heater unit

2. Provides hot water for normal use

3. A safety device that interupts power to the heater elements if tank temperature exceeds a preset point

4. Metal box with cover that serves as a connection point for field and manufacturer's wiring

5. Controls on/off cycle of top element and interupts power to lower element when top element is in the "on" cycle

6. Provides fast recovery of hot water in top of tank

7. To restrict the loss of heat from the tank to the surrounding ambient

8. To maintain spacing between the storage tank and the jacket

9. Fitting provided for the incoming hot water line from solar storage

10. Fitting providing for the installation of a pressure/temperature relief valve

11. Permits hot water from solar storage to enter at the bottom of the tank

12. Fitting provided for the hot water supply to use points

13. Magnesium rod inserted in the tank to reduce corrosion

14. Galvanized steel tank with a glass or stone lining to reduce corrosion of the tank

15. Painted outer cover that provides spacing for insulation, protection for electrical wiring and components, and space for brand name and data plate

6. Match the components of gas fired auxiliary heaters on the left to their correct description.

_____a. Center flue

_____b. Thermostat sensing element

_____c. Thermostat control

_____d. Temperature dial

_____e. Safety pilot

_____f. Thermocouple

_____g. Main burner

_____h. Flue baffle

_____i. Flue opening

_____j. Anode rod

_____k. Jacket

_____l. Cold water inlet

_____m. Hot water outlet

_____n. Relief valve opening

1. Provides source of heat energy when solar cannot meet demand

2. Provides DC power for safety valve operation

3. Magnesium rod inserted in the tank to reduce corrosion

4. Outer housing of heater

5. Provides shut-off of gas input to burner if pilot light goes out

6. Connection point for air diverter and exhaust vent

7. Provides for venting of by-products of combustion to the outside

8. Provides extended contact of flue gases to flue walls for more efficient heating

_____o. Drain valve

9. Connection for piping to use stations

10. Cycles main burner when water temperature matches temperature dial setting

11. Attachment point for temperature/pressure relief valve

12. Connection for piping from solar storage

13. Temperature selection knob

14. Provides pressure difference needed to trip thermostat control when water temperature matches dial setting

15. A boiler valve installed at the tank bottom to flush sediment from the bottom to maintain maximum heat transfer from tank to water

7. Name two types of circulator pumps.

a.____

b.____

8. Name two methods of installing circulator pumps.

a.____

b.____

9. Match the four types of differential temperature controls on the left to their proper description.

_____a. Solid state control--no drain down

1. Equipped with:

a) Tank sensor

b) Plate sensor

c) Freeze protection sensor

_____b. Solid state control--with recirculation for freeze protection

_____c. Solid state control--with drain down freeze protection

_____d. Solid state proportional control--with choice of drain down or recirculation freeze protection

d) Three-way solenoid controlled valve

2. Equipped with three sensors:

   a) Plate sensor

   b) Lower tank sensor

   c) Upper tank sensor

3. Equipped with:

   a) One plate sensor

   b) One tank sensor

4. Equipped with:

   a) One plate atmosphere sensor

   b) One tank sensor

   c) One freeze protection sensor

10. List three options available with proportional controls.

a. ____

____

b. ____

____

c. ____

____

11. Match the different types of heat exchangers on the left to their correct description.

_____a. Tube and shell type

_____b. Emersion type

_____c. Co-axial type

1. Single wall tubing wrapped around the outer tank liner

2. Tube and shell design with the inner tube rifled and the outer tube knurled for greater efficiency

_____d. External wrap-around type

_____e. Double augmented type

3. Remote mounted with:

   a) Fluid from storage directed through the inner tube in an upward direction

   b) Fluid from the collector loop is directed through the outer tube in a downward direction

4. Exchanger mounted inside the storage tank

5. Helical (coiled) design, or trombone design

12. Match the name of commonly used valves on the left to their proper application.

_____a. Boiler drain valve

_____b. Union type isolation valve

_____c. Gate valve

_____d. Globe valve

_____e. Check valve

_____f. Automatic air vent valve

_____g. Vacuum relief valve

_____h. Pressure relief valve

_____i. Temperature and pressure relief valve

_____j. Mixing valve

_____k. Flange type isolation valve

1. Installed in the collector storage piping to prevent back flow of fluids

2. Installed in storage and collector piping for:

   a) Flow rate control down stream from pumps

3. Installed in the collector loop to allow heat transfer fluid to be vented in case the valve setting is exceeded

4. Installed at the bottom of solar storage tanks for draining and flushing

5. Installed at a high point in the collector loop on drain down systems to permit atmospheric pressure to enter the loop to insure drain down when the pumps turn off

6. Installed at the top of storage and auxiliary heaters to protect against those temperatures or pressures that exceed the valves' setting

7. Installed in both the hot water source line and cold water supply line and mixes the two to supply hot water at a selected temperature

8. Installed in storage and collector loop piping for:

   a) Flow rate adjustments

   b) System shut-down

   c) Isolation of pumps or other components

   d) By-pass manifolding

9. Installed between the circulator pump and system piping to isolate the pump and permit fast installation or replacement

10. Installed between the system piping and pumps or other components for ease of installation and/or replacement

11. Installed at a high point in the collector loop to permit air bubbles to escape without loss of transfer fluid

13. Describe the purpose of expansion tanks and name three types.

a. Purpose____

____

____

b. Three types

1) ____

2) ____

3) ____

14. Name six kinds of heat transfer fluids.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

15. Match the four types of absorber materials on the left to their proper description.

_____a. Flat black paint

_____b. Fabric

_____c. Black chrome

_____d. Selective coating

1. Specially designed absorber for high temperature efficiency

2. A high temperature absorber with good efficiency at high collector temperatures

3. A high temperature paint that may be brushed or sprayed on

4. Inorganic material with high energy transmitting ability

16. Name three types of flat plate collectors.

a. ____

b. ____

c. ____

17. Demonstrate the ability to:

    a. Identify mechanical components in a solar hot water system diagram

    b. Complete the piping runs in an incomplete diagram of a solar hot water system

    c. Complete a wiring diagram for a dual element auxiliary heater

    d. Identify control components for a solar hot water system

    (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

SYSTEM COMPONENTS
UNIT I

ANSWERS TO TEST

1. a. 14
   b. 13
   c. 12
   d. 20
   e. 11
   f. 19
   g. 18
   h. 17
   i. 16
   j. 15
   k. 6
   l. 3
   m. 1
   n. 10
   o. 5
   p. 2
   q. 4
   r. 7
   s. 8
   t. 9

2. Any four of the following:
   a. No heat exchanger type
   b. With internal heat exchanger
   c. With remote mounted heat exchanger
   d. With external heat exchanger
   e. With single electric heater element
   f. With dual heater elements

3. a. 62 gallon
   b. 82 gallon
   c. 120 gallon

4. a. Anode rode
   b. Cold water inlet
   c. Hot water outlet
   d. High limit switch
   e. Top thermostat
   f. Heater element
   g. Tank sensor
   h. Drain valve

5. a. 4
   b. 3
   c. 2
   d. 5
   e. 6
   f. 1
   g. 8
   h. 11
   i. 10
   j. 7
   k. 12
   l. 9
   m. 13
   n. 14
   o. 15

6. a. 7
   b. 14
   c. 10
   d. 13
   e. 5
   f. 2
   g. 1
   h. 8
   i. 6
   j. 3
   k. 4
   l. 12
   m. 9
   n. 11
   o. 15

7. a. Direct drive type
   b. Magnetic drive type

8. a. Single
   b. Series

9. a. 3
   b. 4
   c. 1
   d. 2

10. a. Freeze protection by recirculation
    b. Freeze protection by drain down
    c. High temperature limit feature
    d. Output control switch

11. a. 3
    b. 4
    c. 5
    d. 1
    e. 2

12. a. 4
    b. 9
    c. 8
    d. 2
    e. 1
    f. 11
    g. 5
    h. 3
    i. 6
    j. 7
    k. 10

13. a. Purpose: To prevent high pressure build-up of the heat transfer fluid as it expands in a closed loop collector system.

    b. Three types:

        1) Bladder or diaphragm type

        2) Non-diaphragm type

        3) Closed non-diaphragm type

14. a. Potable water

    b. Distilled water

    c. Water/ethylene/glycol mixture

    d. Water/propylene/glycol mixture

    e. Silicone heat transfer fluids

    f. Freon

15. a. 3

    b. 4

    c. 2

    d. 1

16. a. Trickle type

    b. Serpentine coil type

    c. Parallel tube type

17. Performance skills evaluated to the satisfaction of the instructor.

SYSTEM INSTALLATION
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with system installation to their correct definitions and identify system components. The student should also be able to complete an outline diagram of a solar hotwater system collector loop and to install and check operation of a DHW system. This knowledge will be evidenced by correctly performing the procedures outlined on the assignment and job sheets and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with system installation to their correct definitions.
2. Identify four common types of domestic solar hotwater systems from collector array or storage tank outline.
3. Match items indentified with installation procedures for a solar DHW system using electric backup heat
4. List seven methods for mounting flat plate collectors and identify the one recommended for flat roofs.
5. Select the recommended ± variations for orientation of flat plate collectors and list the degree of tilt recommended for maximum winter output.
6. List four applications for silicone flexible connectors.
7. Match statements on hanging and supporting steel.
8. Match R-values to correct insulation types.
9. Select two types of solenoid valves used in a drain down system.

10. Discuss the applications of three voltage values common to domestic solar systems and electric backup heaters.

11. Match statements on proper use of ropes and list five rules for care of ropes.

12. List three methods of roof penetration with a shingled roof.

13. Match statements on recommended types of pipe for a solar system to their proper application and list five methods of connection copper pipe in a solar system.

14. Match statements on safety to their proper application.

15. Demonstrate the ability to:

    a. Identify components from a diagram of a solar hotwater system with drain down freeze protection.

    b. Complete an outline diagram of a solar hotwater system collector loop.

    c. Install a residential solar hotwater system with auxiliary gas heater, drain down freeze protection and frost override.

    d. Check operation of a domestic solar hotwater system with auxiliary gas heater, drain down freeze protection and frost override.

    e. Install a closed loop domestic solar hotwater system using water/glycol transfer fluid, remote mounted heat exchanger and storage tank with electric backup element.

SYSTEM INSTALLATION
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information, assignment, and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Review and discuss transparencies.

   H. Review and discuss films on solar systems. installation, and check out procedures.

   I. Invite local solar dealer/contractor to speak to class on field installations.

   J. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete assignment and job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheets

C. Transparency masters

  1. TM 1--Closed Loop System with Auxiliary Storage
  2. TM 2--Drain Down System
  3. TM 3--Drain Back System
  4. TM 4--Thermosiphon System
  5. TM 5--Spanner Mounting in an Open Attic
  6. TM 6--Spanner Mounting in a Concealed Attic
  7. TM 7--Lag Bolt Mounting
  8. TM 8--Pipe and Rack Mounting
  9. TM 9--Bracket Mounting
  10. TM 10--Upright Mounting (Pitch Pot Method)
  11. TM 11--Collector Orientation and Tilt

  12a. TM 12a--Flexible Connectors

  12b. TM 12b--Flexibel Connectors (continued)

  13. TM 13--Pipe Insulation
  14. TM 14--Knots and Hitches

  15a. TM 15a--Roof Penetration

  15b. TM 15b--Roof Penetration (continued)

D. Assignment sheets

  1. Assignment Sheet #1--Identify Components from a Diagram of a Solar Hotwater System with Drain Down Freeze Protection
  2. Assignment Sheet #2--Complete an Outline Diagram of a Solar Hotwater System Collector Loop

E. Answers to assignment sheets

F. Job Sheets

  1. Job Sheet #1--Install Residential Solar Hotwater System with Auxiliary Gas Heater, Drain Down Freeze Protection and Frost override

2. Job Sheet #2--Check Operation of a Domestic Solar Hotwater System with Auxiliary Gas Heater, Drain Down Freeze Protection and Frost Override

3. Job Sheet #3--Install a Closed Loop Domestic Solar Hotwater System Using Water/Glycol Transfer Fluid, Remote Mounted Heat Exchanger and Storage Tank with Electric Backup Element

G. Test

H. Answers to test

II. References:

1. U.S. Department of Housing and Urban Development, Installation Guidelines for Solar DHW Systems in One-and-Two Family Dwellings, Second Edition, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

2. Budnick, Jim and Richard H. Montgomery, The Solar Decision Book, 1978, Dow Corning Corporation, Midland Michigan 48640.

SYSTEM INSTALLATION
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. Solar hotwater system--A group of components designed and selected to collect, transport, store and deliver hot water

B. Ambient temperature--The temperature of surrounding outside air

C. Auxiliary heat--Heat source provided by conventional heating system when a solar system cannot meet demand

D. Btu (British Thermal Unit)--The amount of heat required to raise the temperature of one pound of water one degree Fahrenheit

E. Closed loop--Any part of a solar system not exposed to the atmosphere

F. Conduction--The flow of heat by contact from one area to another

G. Demand load--Water heating needs to be supplied by solar and/or conventional energy

H. Supply water pressure--Pressure of the portable water within the building from sources not related to the solar hotwater system

I. Double wall heat exchangers--Heat exchangers with two walls between the transfer fluid and portable water in the system

J. Header--Pipe that connects the inlet and outlet risers of an array of collectors to distribute the heat transfer fluid in equal flow rates and pressure to each collector

K. Open system--That part of a solar system open to the atmosphere

L. Pyranometer--An instrument for measuring solar radiation

M. Retrofitting--The addition of a solar hotwater system to an existing hotwater unit

N. Langley--A measure of solar radiation equal to one calorie per square centimeter

O. Insulation--A material with high resistance (R-value) to heat flow

P. Kilowatt--A measure of power equal to one thousand watts

Q. Kilowatt-hour--The amount of energy equivalent to one kilowatt of power being used for one hour: 3.413 Btu's

R. Tilt angle--The angle that a flat plate collector surface forms with the horizontal plane

S. Trickle-type collector--A collector in which the heat transfer fluids flow in open channels on the absorber

T. Tube-type collector--A collector in which the heat transfer fluid flows through metal tubes that are fastened to the absorber plate by solder, clamps, etc.

U. Ultraviolet radiation--Radiation with wave length slightly shorter than visible light

V. Tube-in-plate collector--An absorber plate in which the heat transfer fluid flows through passages formed in the plate itself

W. Solar pathfinder--A device used to chart shading effects when selecting placement and orientation of collectors

X. Solar site selector--Visual solar calculator and site selector device that determines solar access

Y. Liquid-type collector--A collector using a liquid as the heat transfer fluid

Z. Stagnation temperature--High temperature that results when fluids or gases in a non-moving or stagnation condition are exposed to solar heat gain for extended periods of time

II. Types of domestic solar hotwater systems in common use

  A. Closed loop system with auxiliary storage (Transparency 1)

    1. Storage tank--A vessel selected or built to hold the solar heated water

       (NOTE: Most domestic tanks will be stone or glass lined built to match the existing or new standard water heater.)

    2. Auxiliary heater--Electric, gas or oil fired heater used as backup system to support the solar storage capacity

       (NOTE: The solar storage tank will generally be connected to serve as a preheater for the auxiliary heater with the cold water supply entering the solar storage tank thus allowing for use of all solar energy collected.)

    3. Flat plate collectors--Collectors used with domestic systems due to lower temperatures required and the higher cost of concentrator type plates

    4. Expansion tank--A vessel installed in closed collector loops to allow for expansion of fluid due to increased temperatures

       (NOTE: The expanded fluid is stored in the expansion tank thus eliminating pressure build up in the collector plate and lines.)

    5. Circulator pumps--Electric driven pumps used to circulate fluids through the collector and storage loops

    6. Heat exchangers--A device installed in the collector and storage loops to permit the transfer of heat energy from the heat transfer fluid to potable water

    7. Pressure relief valve--A pressure sensing device installed in the collector loop to permit release of transfer fluid if system pressure reaches a preset value

(NOTE: A pressure relief valve is a safety device installed to protect the collector and piping from damaging pressures that could result under certain stagnation conditions.)

8. Automatic air vents--A device installed at a high point on the collector loop to automatically release trapped air from the collector loop

   (NOTE: These valves may also be installed on top of storage tanks with air heads and air eliminator valves.)

9. Water pressure gauges--A device installed in the collector and storage loops to indicate the amount of pressure in each system

10. Inline thermometers--Direct reading device that indicates temperature of fluids at the point of contact

    (NOTE: This type component is not a required item for system performance or safety but does provide the customer or maintenance person with instant data on system temperatures.)

11. Mixing (tempering) valve--A device installed between the solar heated water storage and use stations to mix hot and cold water to a selected temperature before it is piped to the point of use

    (NOTE: Valve setting selection will usually be from 110° F to 160° F.)

12. Differential temperature control--A device that uses very low voltage circuits to control circulator pump operation

    (NOTE: This type control may operate the pump on/off cycle for heat collection and provide freeze protection control of pump and/or drain down valves also.)

13. Boiler drain valves--Manually operated valve with hose threads to connect hoses for draining, flushing and/or charging of heat transfer fluids in a solar system

    (NOTE: This type valve is used on water heaters and other liquid storage tanks for draining and cleaning purposes.)

14. Gate valves--Manually operated valves installed in both collector and storage loops to isolate or control fluid flow within the system

15. Check valves--A device installed in the collector loop to insure fluid flow in one direction only

16. Air eliminator valve--A device designed to be installed in the collector loop between the storage tank and circulator pump and equipped with an automatic air vent valve is mounted on top of the expansion tank to aid in removal of air from the loop

17. Globe valve--A manually operated valve installed down stream from the circulator pump to adjust flow rate of transfer fluid to the collector bank

18. Temperature and pressure relief valve--Temperature and pressure sensing safety device preset to open when tank pressure or water temperature reaches the relief setting

19. Back flow preventer--Special type check valve installed between the incoming cold water supply and the hotwater system to prevent possible contamination of the supply system in case of pressure loss

    (NOTE: A check valve is not a substitute for an approved back flow preventer.)

20. Strainer--A device installed in the collector supply line to filter the fluid entering the circulator pump

21. Sensors--Temperature sensing devices installed in the collector plate and solar storage tank to determine the cut-on and cut-off cycle of the circulator pump

22. Dip tubes--Internal pipe that permits the inlet water to flow into the tank near the bottom

    (NOTE: This tube will normally be marked "cold" or "cold in" at the top of the tank.)

23. Auxiliary element--230 volt resistance heater units that provide hot water back-up for the solar system

B. Drain down system (Transparency 2)

1. Collectors--Flat plate pressurized type with fluid inlet at the bottom

   (NOTE: Most systems will be equipped with one-to-two collectors with 40 to 60 square feet of collector surface.)

2. Vacuum breaker--A device to insure proper drainage of the collector loop when the 3-way valve is open to the drain port

3. Frost cycle sensor--A temperature sensing device that permits the differential thermostat to switch to the drain down mode when freezing conditions are present

4. Normally closed solenoid valves--Electrically controlled valves that are closed by the differential control thermostat during the drain down mode

   (NOTE: A normally closed solenoid valve is installed in both the collector loop supply and return lines.)

5. Normally open solenoid valve--Electrically operated 3-way valve that permits draining of the collector loop to prevent freezing

   (NOTE: This type valve is used in systems that circulate potable water from the storage tank and should be piped into an open drain.)

C. Drain back system (Transparency 3)

1. Collectors

a. Flat plate with tubing--The absorber is constructed of metal tubing painted with an absorber coating

(NOTE: Metal tubing may be copper, steel or aluminum and connected into manifolds or be formed into one single tube.)

b. Flat plate with metal channels--The absorber is constructed of sheet metal with ridges and coated with an absorber coating

(NOTE: This type plate requires that the inlet be at the top of the plate, allowing the transfer fluid to flow by gravity back to the storage tank.)

c. Flat plate with fabric absorber--The absorber is constructed from a fabric and requires no coating

(NOTE: With this type collector the transfer fluid is pumped to the top of the collector/s and flows by gravity between the fabric and a metal surface and back to the open storage tank.)

2. Level gauge--A glass or plastic tube that shows the water level in the storage tank

3. Thermometer--An optional device that registers temperature of the inlet water from the collectors

4. Fill valve--Valve used to add water to the storage tank

D. Thermosiphon system (Transparency 4)

1. Collectors--Pressurized type capable of operating under supply line pressure

(NOTE: This type system may be designed to operate with a heat exchanger and non-potable transfer fluids.)

2. Piping--3/4" or larger pipe should be used in the collector return line to allow for free flow of the heated fluid

3. Collector return line--Should enter the storage tank at a minimum distance from the top

4. Storage tank location--Tank must be elevated above the top of the collectors a minimum of 18"

5. Freeze protection--If potable water is used as the heat transfer fluid, a shut-off valve must be installed in both the collector inlet and outlet line plus a drain valve at the low point of the inlet manifold for draining the system if freezing conditions are expected

6. Tank drain valve--A boiler drain valve is installed at the tank bottom to drain and/or flush the tank

III. Installation procedures for a domestic solar hot-water system using electric backup heater

A. Procedures to include development of:

1. Major component location diagram:

a. Collectors--Should identify the exact location and orientation of each collector

b. Storage tank--Should identify the exact location of the storage tank--basement, closet, utility room, etc.

c. Auxiliary heater--The auxiliary heater should be located as close as possible to the solar storage tank

d. Expansion tank--Locate the expansion tank close to the solar storage tank if possible and at a point for good support

e. Remote-mounted heat exchanger (if used)--Locate the heat exchanger as close as possible to the solar storage tank

(NOTE: The heat exchanger should be mounted with brackets secured to the wall.)

f. Circulator pumps--Location of each pump should be clearly identified with method of mounting and supporting

g. Differential temperature control--This control should be located as close as possible to the storage tank or mounted directly to the tank

2. Piping diagram

a. Components--Location of each component should be identified with piping connections completed

b. Valves and fittings--Each valve and fitting should be identified and located with piping connections completed

3. Electrical diagram

a. Wiring for field installation of:

1) Storage tank--Should include branch circuit wiring to the differential temperature control and pumps

2) System control--Should include all sensor leads and solenoid valve wiring

3) Auxiliary heater--Should include branch circuit wiring for the auxiliary heater elements

(NOTE: Local electrical codes may require that a licensed electricain install all power wiring for both the solar system and auxiliary heater.)

4) Circulator pumps--Should include power wiring to all pumps

4. Materials and supplies list

a. Materials--Should include the required amount of piping, valves, fittings, pipe insulation, wiring materials, sensors, gauges, etc.

b. Supplies--Should include the required amount of pipe hangers, straps, screws, etc. to secure all items in place

IV. Methods of mounting flat plate collectors

A. Spanner mounting in an open attic (Transparency 5)

1. 2" X 4" spanners are secured directly to the rafters inside the attic, perpendicular to the rafters

(NOTE: The number of bolts required will determine the number of spanners used.)

2. Wood spacer blocks the same size as the rafters should be installed on each side of threaded rods to prevent spanner sag when bolts are tightened

3. 3/8" diameter threaded rods are inserted through the collector mounting angle, mounting block and roof and tightened down with two nuts and large spacer washers on each end

(NOTE: Mounting blocks should be 2" X 4" redwood or cedar.)

4. Silicone sealant should be applied generously to holes, bolt top, between washers and mounting block and mounting block and roof

5. Collector plates should then be bolted to mounting angles with rust proof bolts

B. Spanner mounting with concealed attic (Transparency 6)

1. Selected areas of the ceiling are removed to expose the rafters

2. Secure 2" X 4" wood blocks to inside of rafters 3 inches from the ceiling edge

3. Secure the spanner in place with the holes for the threaded rod aligned with each other

(NOTE: Prior arrangement with the customer should be made before any cuts are made in the ceiling.)

4. Install 2" X 4" wood spacers on each side of threaded bolt hole to prevent sagging of the spanner as bolt is tightened

5. Complete installation as in procedures under open attic

6. Repair and refinish open areas in ceiling

   (NOTE: It may be necessary to have a carpenter and painter repair the ceiling.)

C. Lag bolt mounting (Transparency 7)

   1. Use lag bolts long enough to provide at least 2" penetration of rafter

   2. Use silicone sealant, mounting block, galvanized and neoprene washers and collector mounting angle as with the spanner method

      (NOTE: Roofing cement is sometimes used to cover bolt heads instead of silicone sealant.)

D. Rack mounting (Transparency 8)

   1. Mounting racks are bolted to the roof and adjusted to the correct tilt angle

   2. Collectors are bolted to the racks with bolts selected that will not rust and control galvanic corrosion

   (NOTE: Racks may be constructed from slotted angle rail material normally used to fabricate warehouse shelving.)

E. Pipe mounting (Transparency 8)

   1. Galvanized or aluminum pipe and fittings that use set screws are used to fabricate the mounting frame

F. Bracket mounting (Transparency 9)

   1. Special mounting brackets are bolted to the roof using lag bolts secured to the rafters or threaded rods and spanners

   2. The collectors are mounted to the brackets using predrilled holes that provide a minimum clearance of 1/2" between the collector bottom and the roof

G. Upright mounting for flat roofs (Transparency 10)

1. A galvanized pipe is welded to a square base with mounting holes

2. The base is placed inside a pitch container with a flashing lip

   (NOTE: This container is called a pitch pot.)

3. The base and container is bolted to the roof using the lag bolt or spanner method

4. Flashing is secured to the base and sealed with roofing cement

   The base container is filled with pitch or roofing cement

6. The collectors are mounted to framing attached to the upright

   (NOTE: Pitch pots do not necessarily have lasting water tight qualities and should be inspected whenever maintenance is pulled on the system.)

V. Collector orientation and tilt (Transparency 11)

A. Collector orientation

1. Collectors should be aimed within 15°± of true south

   (NOTE: Deviations of more than 15°± should be avoided if possible. However, deviations of up to 25° may only decrease performance by 10% in a well designed system.)

B. Collector tilt

1. Maximum winter output

   a. The collector should be tilted above the horizon 12° to 15° more than the degree of latitude on which the installation site is located

      (NOTE: Variance from the recommended tilt can result in significant loss in output by most flat plate collectors.)

2. Maximum summer output

   a. The collectors should be tilted below the horizon 12° to 15° more than the degree of latitude on which the installation site is located

      (NOTE: For hotwater systems only the best tilt should be a compromise between the summer and winter maximum points.)

VI. Flexible connectors

A. Silicone coupling hose (Transparency 12)

1. May be used to:

   a. Connect collectors end to end

   b. Connect collectors to piping manifolds

   c. Serve as expansion joints

   d. Connect dissimilar metal piping to prevent galvanic corrosion

   (NOTE: Silicone hoses should be clamped with lined (non-perforated) stainless steel hose clamps.)

B. Automobile radiator hose

1. May be used to:

   a. Connect misaligned piping in limited applications not exposed to sunlight

      (NOTE: Radiator hose is not generally recommended for solar applications.)

C. Metal bellows type flexible connectors (Transparency 12)

1. May be used to:

   a. Connect collectors end to end

   b. Connect collectors to piping manifolds

   c. Serve as expansion joints

      (NOTE: These are sweat type connectors.)

VII. Hanging and supporting steel, copper and plastic pipe

- A. Copper pipe
  - 1. Vertical runs--Support at ten foot intervals
  - 2. Horizontal runs
    - a. Eight foot intervals for hard copper
    - b. Six foot intervals for annealed copper
- B. Threaded steel pipe
  - 1. Vertical runs--Support at twenty foot intervals
  - 2. Horizontal runs--Support at twelve foot intervals
- C. Rigid plastic pipe
  - 1. Vertical runs--Support at five foot intervals
  - 2. Horizontal runs--Support at one-to-two foot intervals

VIII. Pipe insulation (Transparency 13)

- A. Types common to DHW system
  - 1. Fiberglass
  - 2. Elastomers

    (NOTE: Common elastomers are Armaflex^R, Rubatex^R, etc.; also, referred to as foam insulation.)
  - 3. Urethane
- B. Insulating value per inch of thickness of selected pipe insulation
  - 1. Fiberglass--R-3 or K-.26
  - 2. Elastomers--R-3.5 or K-.23

3. Urethane--R-6.5 or K-.17

(NOTE: The higher the R-value or the lower the K-value of a material the better the insulating ability.)

IX. Solenoid valves for freeze protection drain down systems using potable water

A. Three-way solenoid operated valve

1. Electrically operated valve

2. Drain port of valve is in the open position when electrical power to valve is "off"

3. Valve drain port is closed during normal operation

4. Valve operation is controlled by the differential temperature control

B. Normally closed solenoid valves

1. Installed in the collector return line down stream from the three-way valve loop

(NOTE: This valve prevents storage tank water from draining through the three-way valve during the system "off" cycle.)

2. Installed up stream from the circulator pump

(NOTE: This valve closes when the three-way valve opens and prevents water input to the collector loop during the "off" cycle.)

X. Voltage values common to domestic solar systems and electric backup

A. 115 volts

1. Operates the input side of most differential temperature controls

2. Operates the circulator pumps

3. Operates most solenoid operated valves

4. Operates the power "on" indicator bulbs on many controls

B. 24 volts

1. Operates the output side of most differential temperature control relays

2. Operates the circuits "on" indicator bulbs on some differential thermostats

C. 230 volts

1. Used to operate the electric elements on solar storage tanks equipped with backup electric elements

2. Used to operate the electric elements on electric auxiliary heaters

3. Used to operate some circulator pump motors

XI. Proper use and care of ropes (Transparency 14)

A. Knots and hitches

1. Figure eight knot--Used in the end of a rope to temporarily prevent the strands from unlaying

(NOTE: May also be used to prevent the end of a rope slipping through a block or an eye.)

2. Square knot--Used to join two ropes or lines of the same size

(NOTE: This is also known as the roof knot.)

3. Sheet bend--Used to join ropes together or to attach a rope to an eye hook

(NOTE: This knot is also known as the weavers knot.)

4. Bowline--Is easily constructed and used whenever a loop is required that will not slip, jam or fail

5. Timber hitch--Very useful for hoisting boards, pipe or other objects requiring a knot that will not slip or jam

6. Clove hitch--Used to hold pipe and frame members in place for assembling, etc.

   (NOTE: This knot is also known as a builders hitch because of its wide use by builders.)

B. Care of ropes

1. Avoid overloading--Do not exceed safe working load

2. Avoid kinks and sharp angles--Rope is weakened at these points

3. Avoid chemical contact with rope--Natural fiber ropes such as manila can be severly damaged by chemicals; synthetic ropes are less effected

   (NOTE: For added safety keep all ropes free of chemicals.)

4. Avoid prolonged exposure to direct sunlight--Nylon, poly and polyester ropes are severely weakened by prolonged exposure to ultra violet rays

5. Keep rope clean--Wash with clean water to maintain longer life and maximum strength

6. Use proper size pulleys--Rope will wear escessively when used with pulleys that are too small

XII. Roof penetration-Shingle roof

A. Copper flashing and pipe stub (Transparency 15a)

1. A short length of copper tubing is inserted through a copper sheet and soldered, providing a stub on both sides of the sheet for attaching the collector loop piping

2. A short length of smaller size tube with a 180° bend is inserted into the same sheet and soldered. This provides a passage for the collector sensors through the roof

   (NOTE: Flashing with single pipe stub is also available and installed in the same manner.)

B. Neoprene boot and flange (Transparency 15b)

1. The boot and flange are installed with the top of the flange under the shingles and the bottom over the shingles

2. Sealant is applied between the flange and shingles and around base of the pipe

(NOTE: The neoprene collar flanges do not require a sealant where the pipe passes through and the collars are adjustable to any roof pitch.)

C. Reducers and plastic nipple method (Transparency 15b)

1. A neoprene flange is installed and sealed

2. A plastic nipple is installed through the roof opening and the flange

3. Plastic reducers are installed on each end of the plastic nipple

4. The pipe is inserted through the reducers and nipple

5. Sealant is applied between the pipe and reducer on the roof side

6. Pipe insulation is installed on the pipe in the usual manner

(NOTE: If the pipe insulation has a rigid casing, the nipple and reducers can be eliminated.)

XIII. Recommended types of piping and methods of connecting

A. Copper pipe

1. Type L hard copper--Available in twenty foot lengths

2. Type L soft copper--Available in coils of 25', 50', and 60' lengths

(NOTE: Soft copper is also referred to as annealed copper.)

3. Type M hard copper--Available in twenty foot lengths

   (NOTE: Type M hard copper and type L soft copper may be prohibitied by local codes for use in solar systems.)

B. Plastic pipe

1. PVC pipe is recommended for cold water use only

2. CPVC is rated for hotwater use to about 180° F, but will require careful support if used in the collector loop

   (NOTE: Do not expose CPVC pipe to stagnation temperatures or prolonged exposure to sunlight.)

C. Galvanized threaded pipe

1. Available in twenty-one foot lengths

2. Recommended for hot and/or cold water service for special applications

(NOTE: Do not use galvanized pipe in collector loops using water/glycol solutions.)

D. Methods of connecting copper pipe

1. Sweat joints made with 95-5 tin antimony solder and non-acid flux

2. Threaded joints using Teflon^R tape

3. Threaded joints using a quality compound such as Loctite^R pipe dope with Teflon^R

   (NOTE: If the heat transfer fluid is silicone or a water/glycol solution, standard pipe dope will not provide a leak proof joint.)

4. Sweat joints made with silver solder

5. Sweat joints made with a silver-bearing solder

6. Sweat joints made with brazing alloys

(NOTE: Local codes may require the use of a specific alloy for certain piping runs; check local codes before starting a job.)

XIV. Safety

A. Electrical

1. Must meet local code requirements

2. The system controller should have its own properly grounded and protected power circuit

B. Maintenance personnel safety

1. Components should be located so as to insure safe, easy access to all major system components

C. Pedestrian and visitor safety

1. All surfaces with operating temperatures above 120° F that cannot be insulated should be marked as potential hazards to prevent burns

2. All temperatures and/or pressure relief valves should be located to vent into a safe area

3. All piping exposed to possible contact by individuals on the ground should be supported well enough to prevent damage by carelessness or children

D. Heat transfer fluid safety

1. Should be discharged into dry well storage or sanitary drain in a manner acceptable to local codes

2. A harmless dye should be added to all toxic or non-potable heat transfer fluids

3. All outlets and faucets or non-potable or toxic fluid lines should be wired closed and tagged "Danger - Not Drinkable"

4. Ends of pipes draining heat transfer fluids should not be threaded

5. There should be an air gap of at least six inches between the ends of all piping used to drain toxic fluids and the drain point

   (NOTE: Local codes may also require a back flow preventer at the cold water inlet to prevent direct connection between the potable water supply and system waste.)

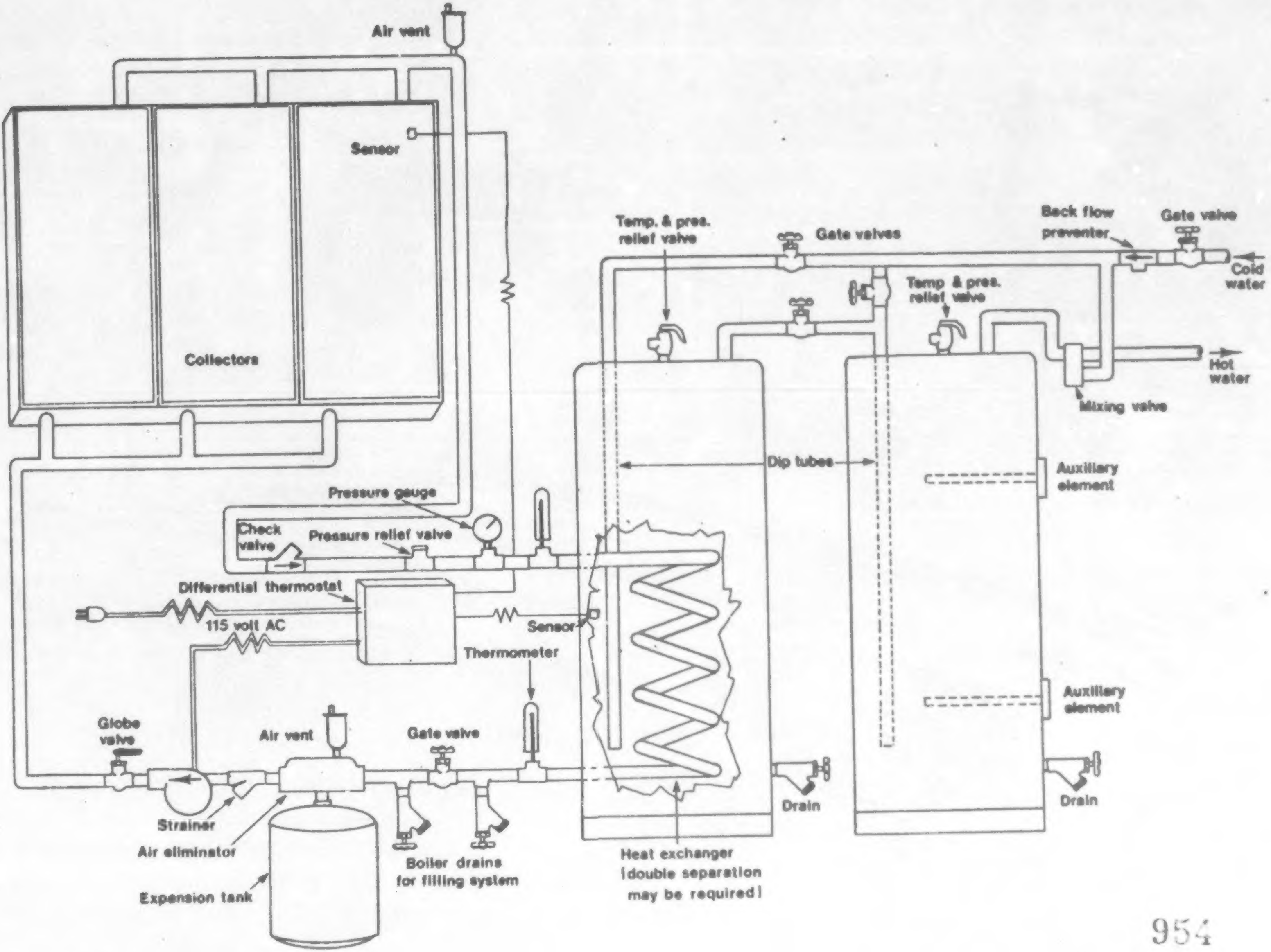
6. A double wall heat exchanger is required with all systems using a toxic heat transfer fluid

E. User safety

1. A tempering valve should be installed on each hotwater system to control the temperature of water directed to the use points to prevent possible scalding

2. The vacuum relief valves required to prevent the possible collapse of storage or expansion tanks must not be allowed to freeze

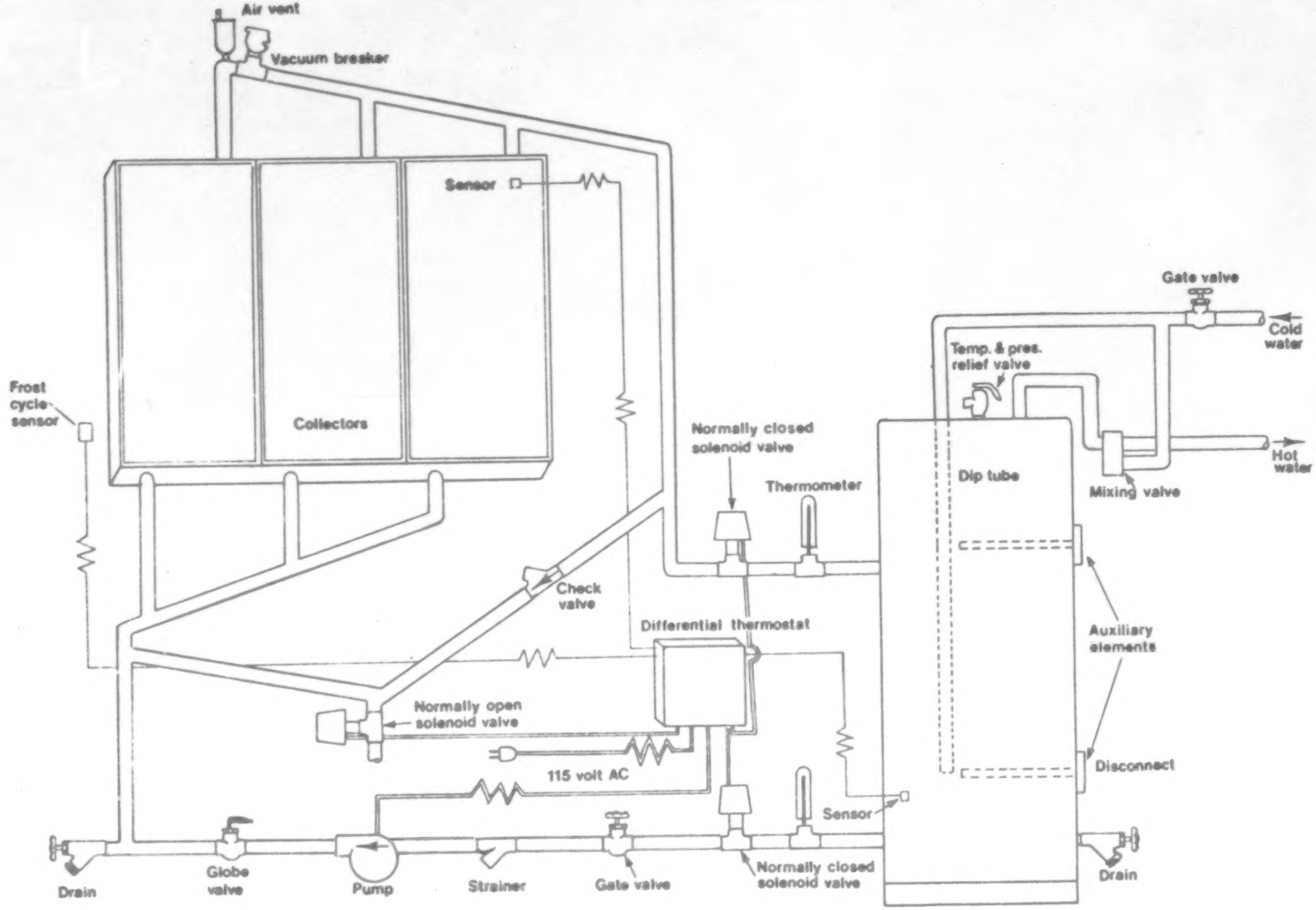
CLOSED LOOP SYSTEM WITH AUXILIARY STORAGE



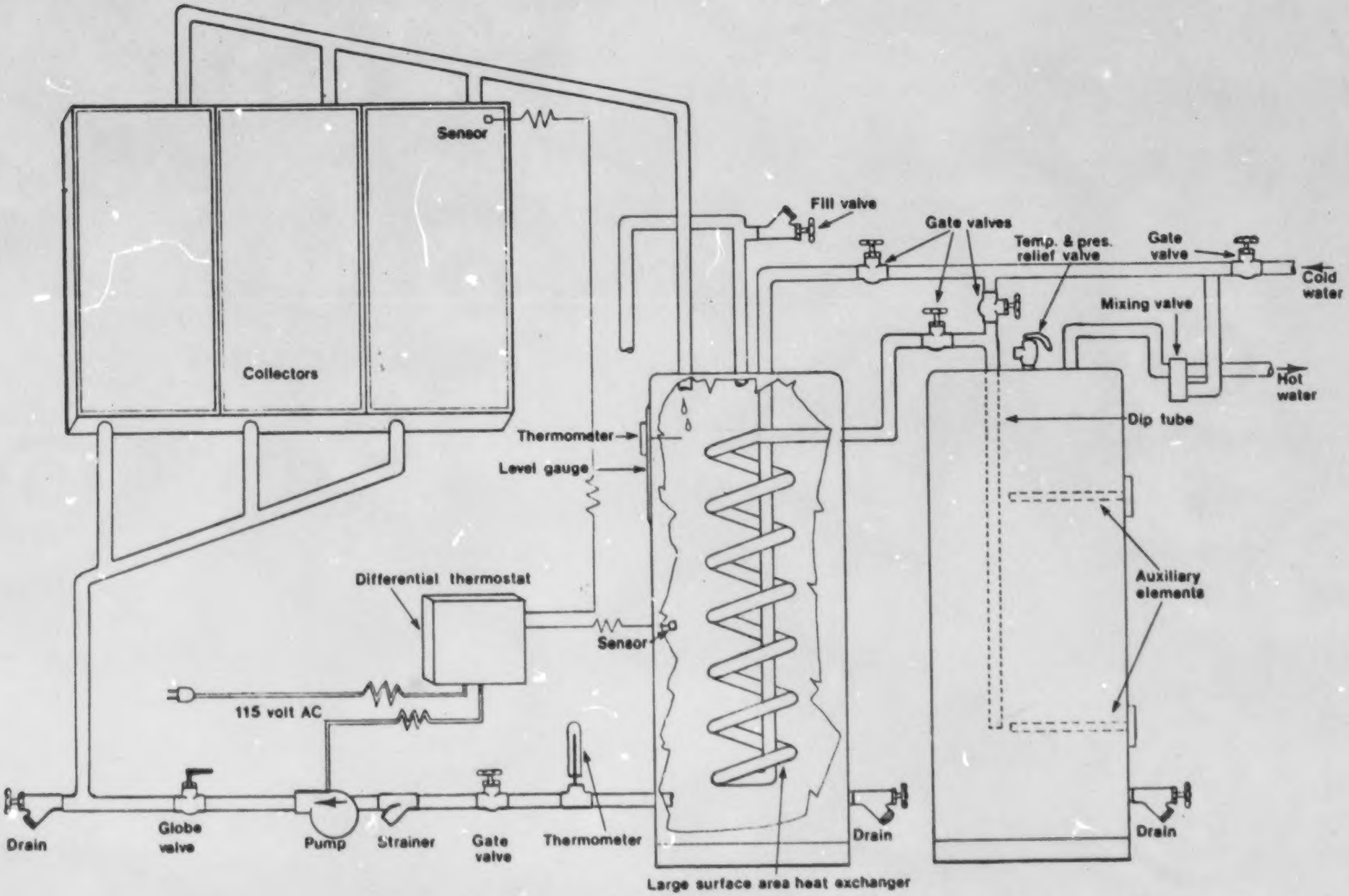
TM 1

S-143-H

DRAIN DOWN SYSTEM



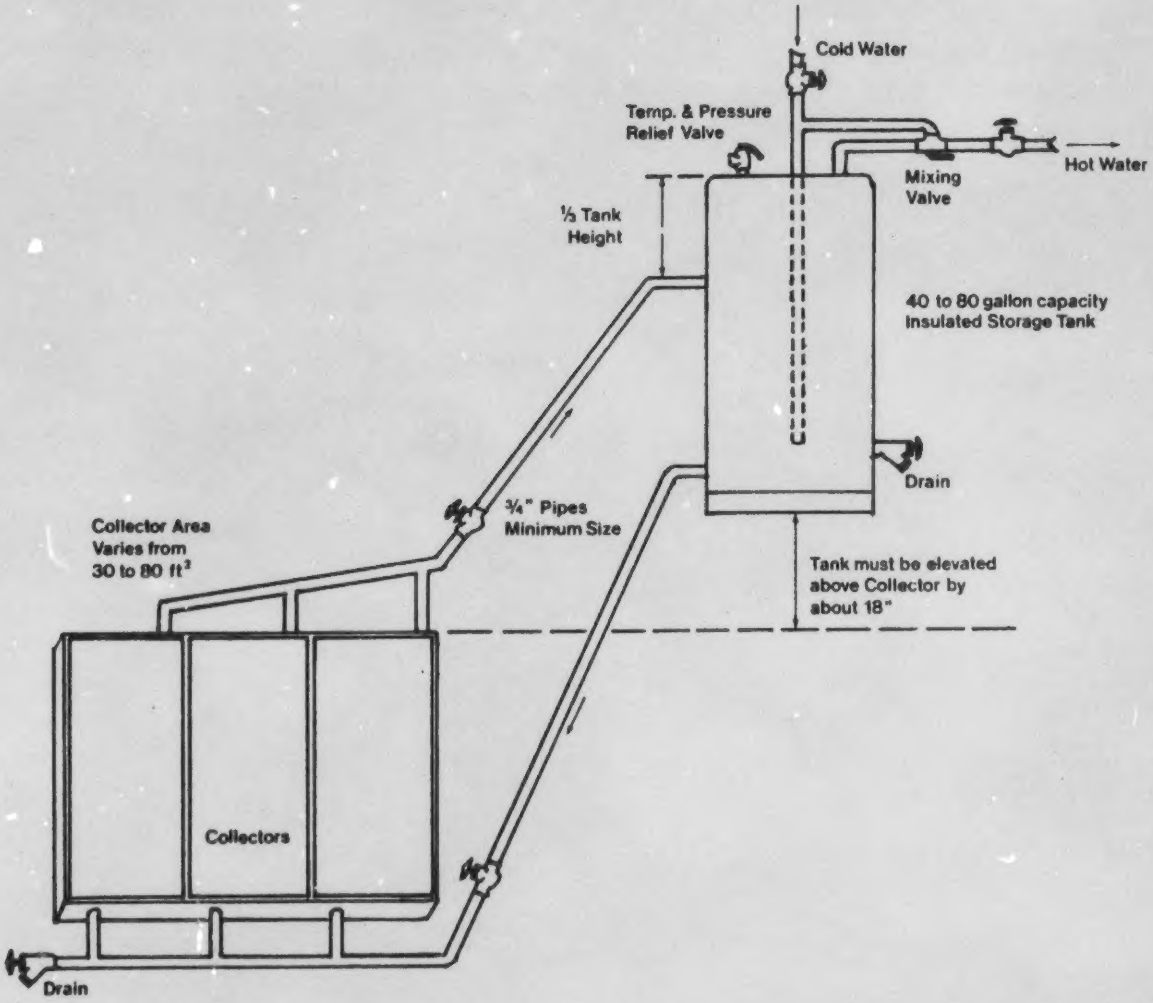
DRAIN BACK SYSTEM



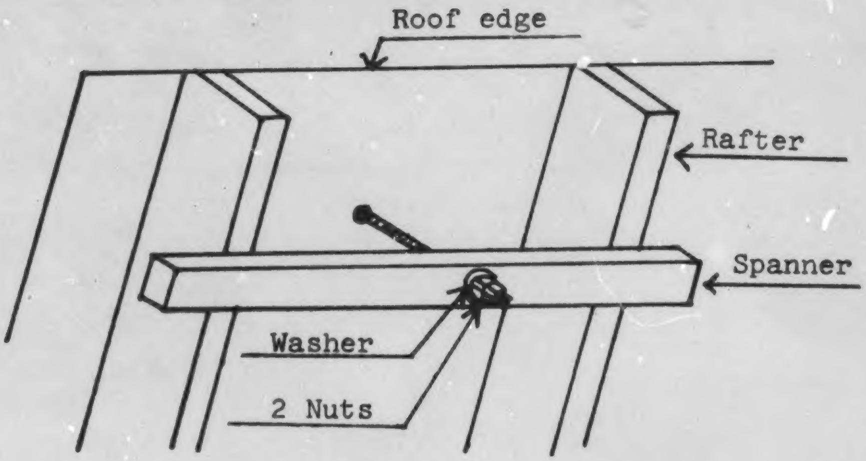
TM 3

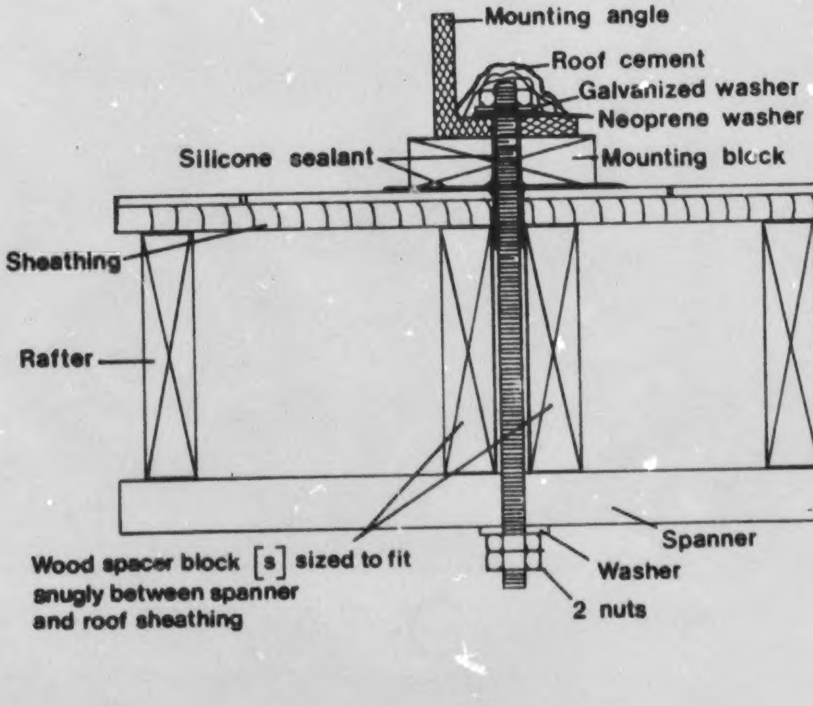
S-147-H

THERMOSPHION SYSTEM

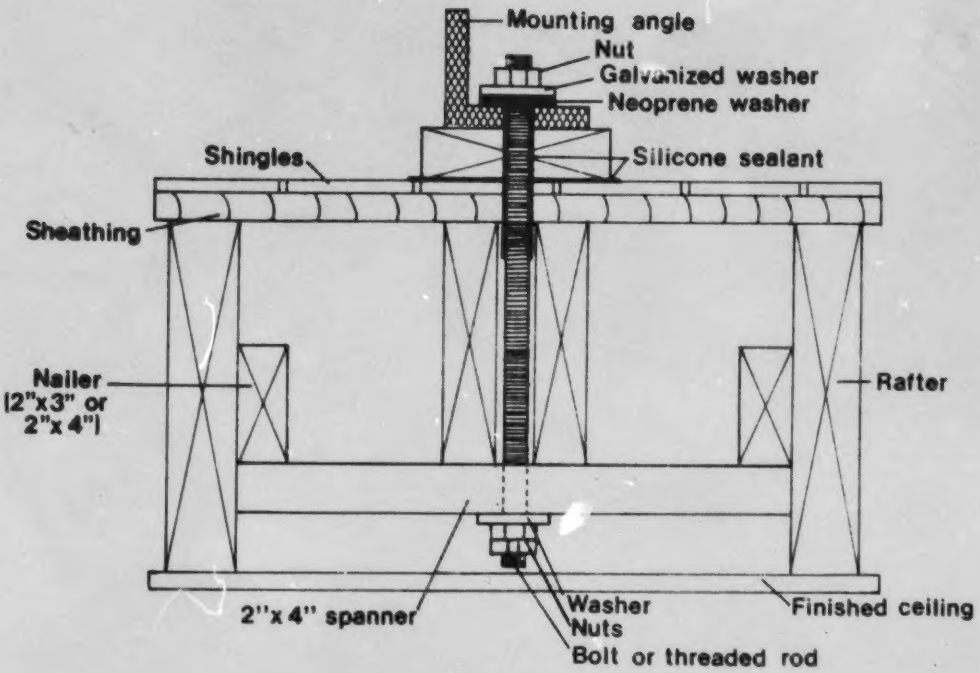

Cold Water
Temp. & Pressure Relief Valve
Mixing Valve
Hot Water
⅓ Tank Height
40 to 80 gallon capacity Insulated Storage Tank
Drain
¾" Pipes Minimum Size
Collector Area Varies from 30 to 80 ft²
Tank must be elevated above Collector by about 18"
Collectors
Drain

SPANNER MOUNTING IN AN OPEN ATTIC

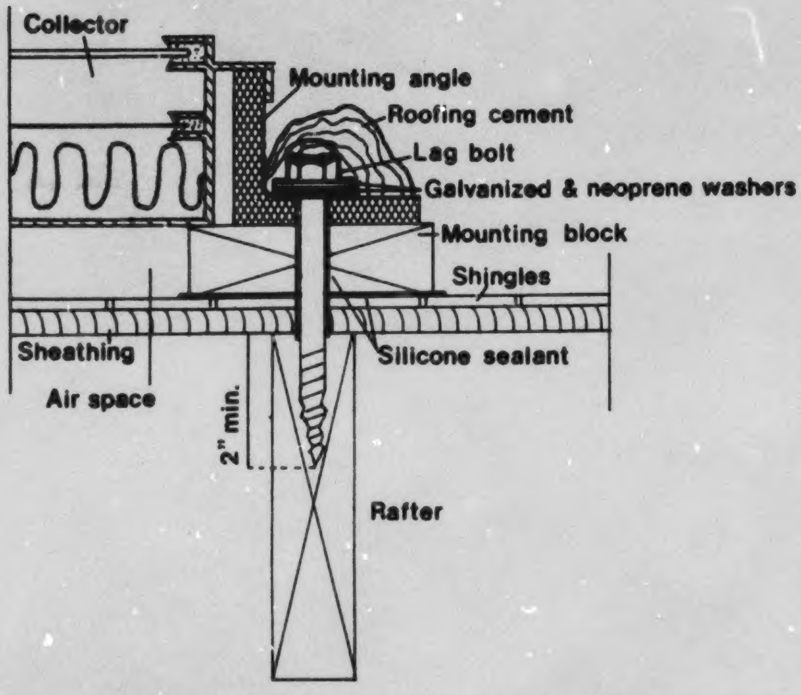




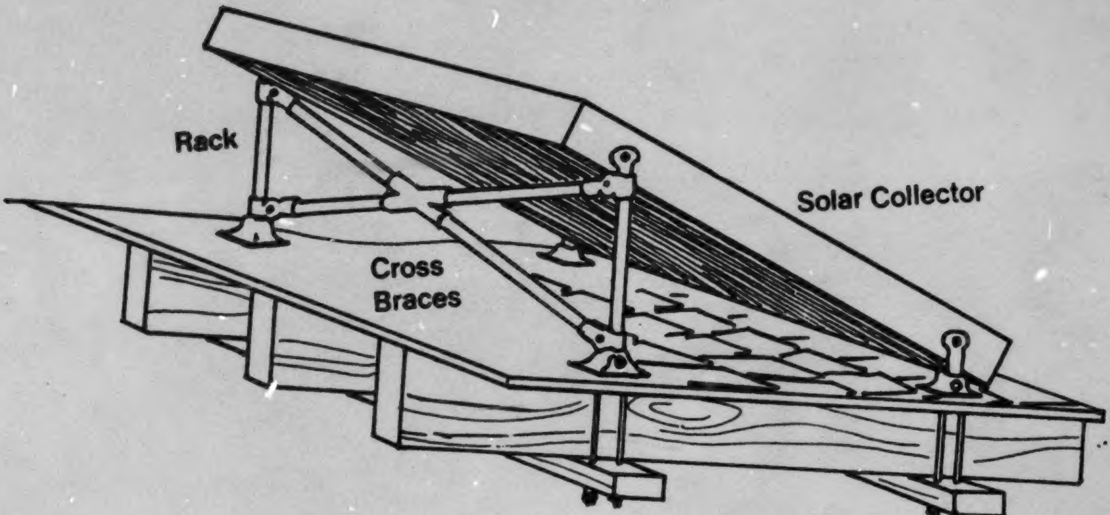
SPANNER MOUNTING IN A CONCEALED ATTIC

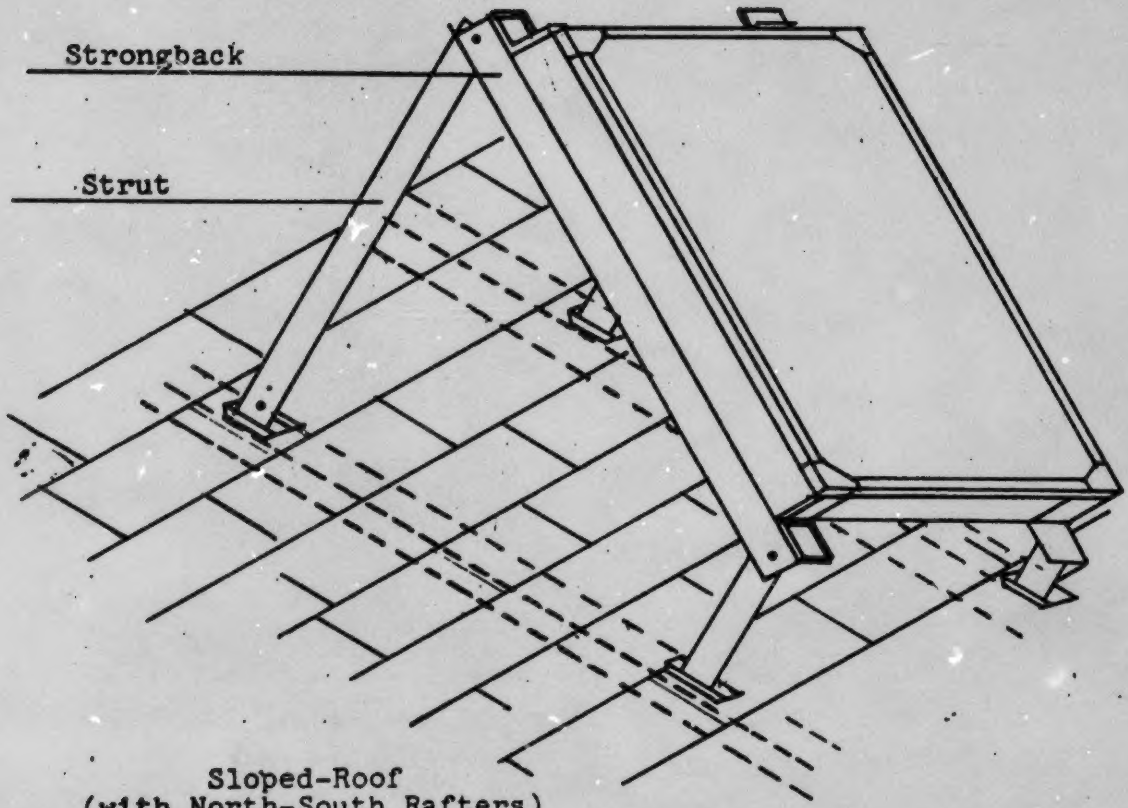


LAG BOLT MOUNTING



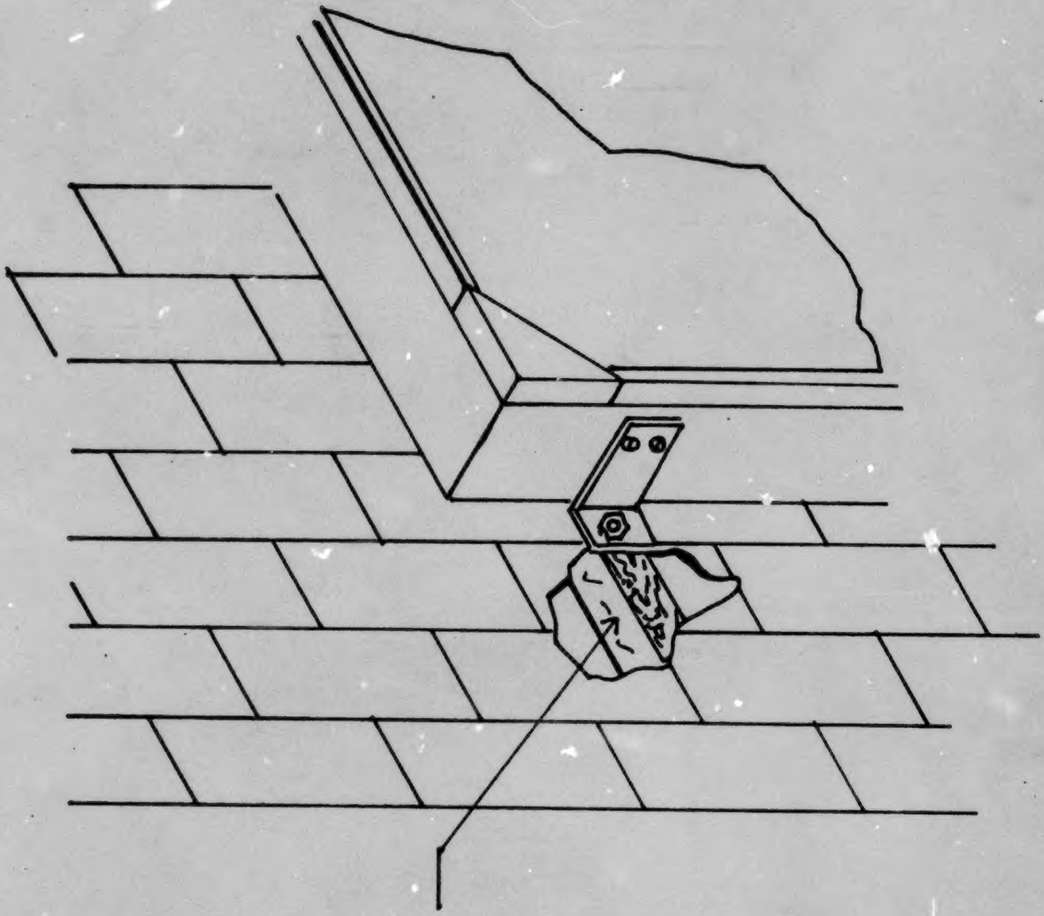
PIPE AND RACK MOUNTING





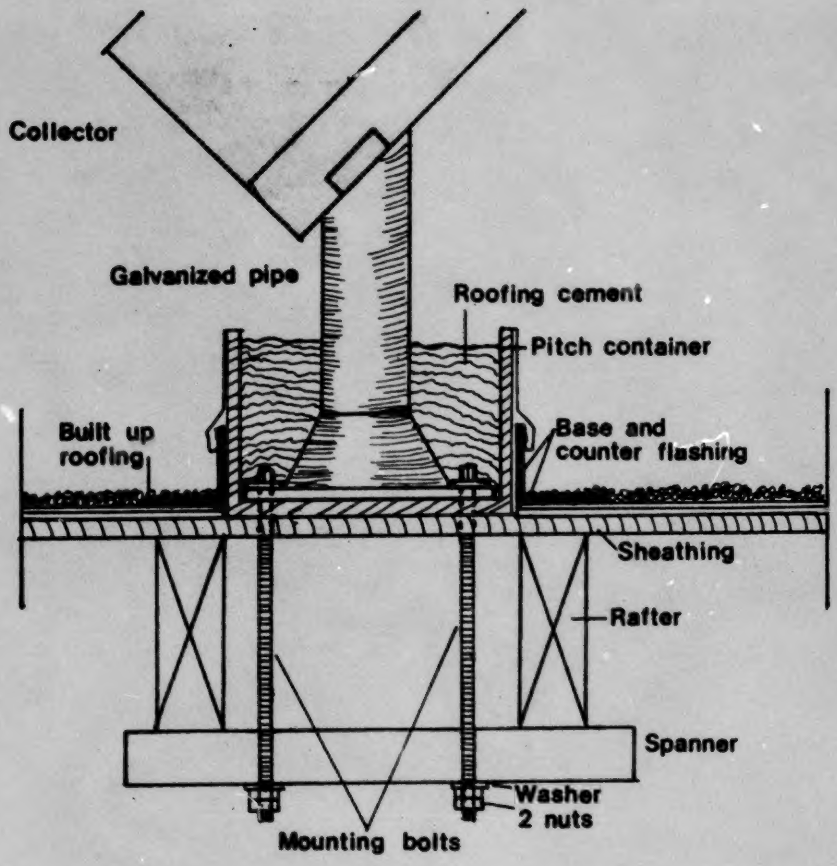
Sloped-Roof
(with North-South Rafters)

BRACKET MOUNTING

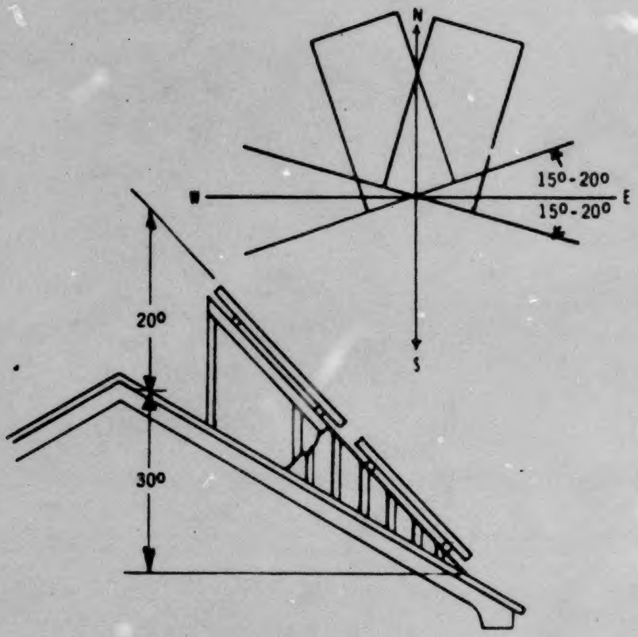


UPRIGHT MOUNTING

(PITCH POT METHOD)

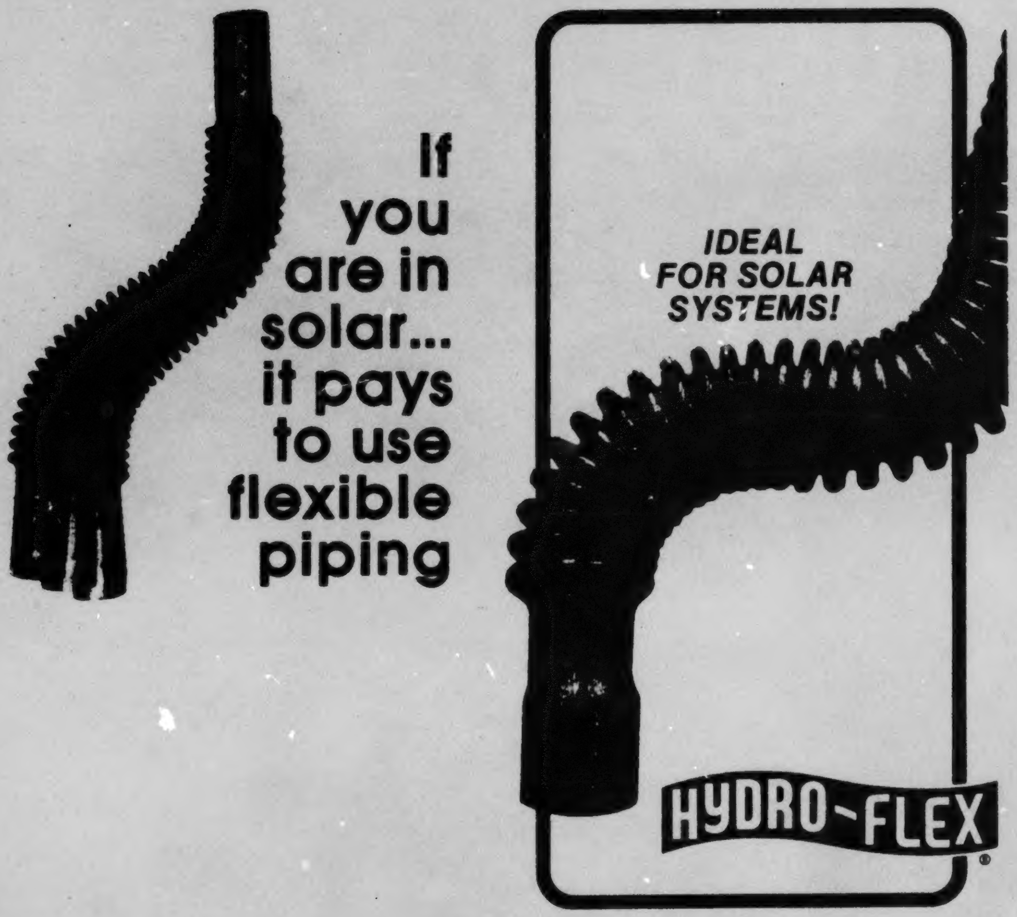


COLLECTOR ORIENTATION AND TILT



Orientation of collector panels. Top, permissible orientation of collector from true south. Bottom, optimum tilt for collector may require roof structure. In the illustration, a 30° roof pitch is increased 20° by a special roof structure for collector panels.

FLEXIBLE CONNECTORS



Courtesy of

Hydro-Flex Corporation

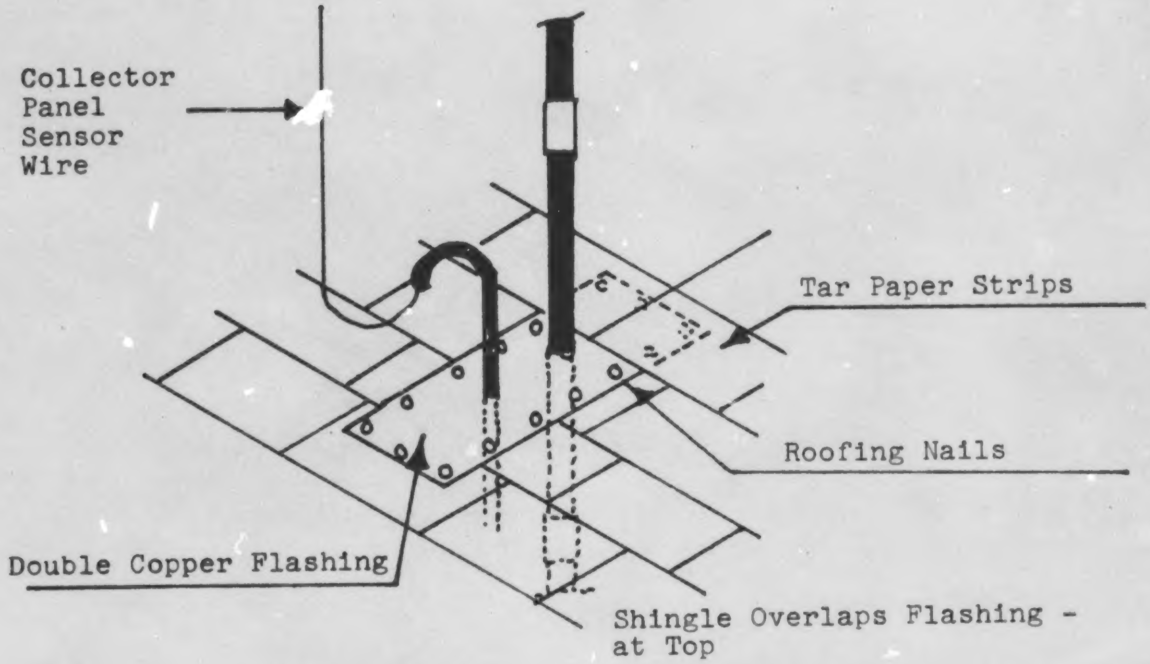
FLEXIBLE CONNECTORS
(CONTINUED)

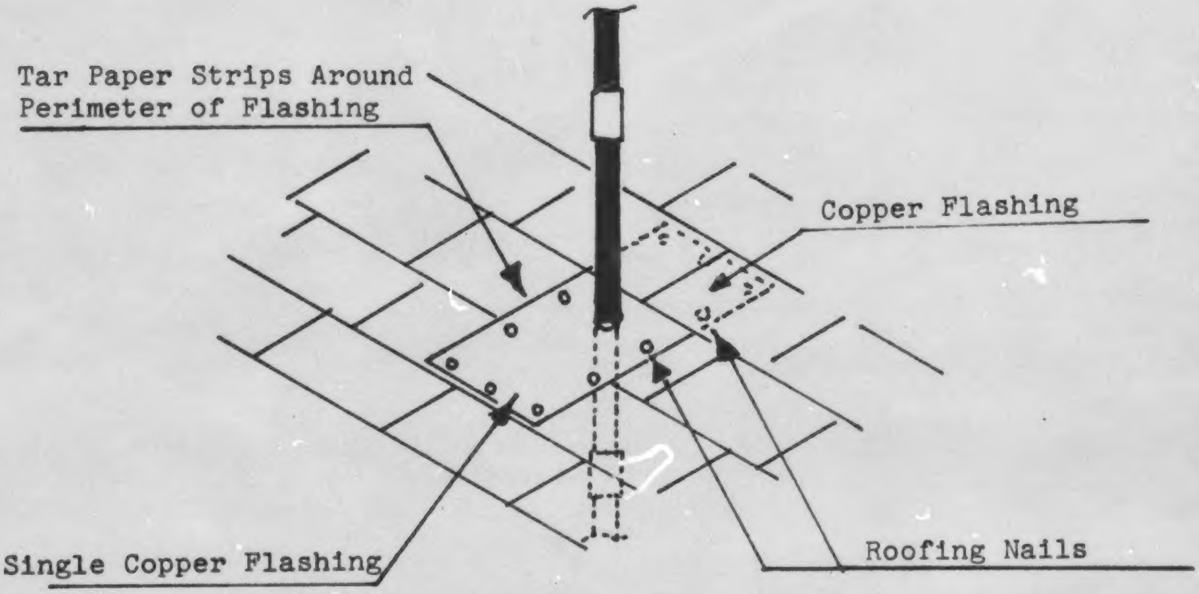
Courtesy of
Chase-Walton Elastomers, Inc.

PIPE INSULATION

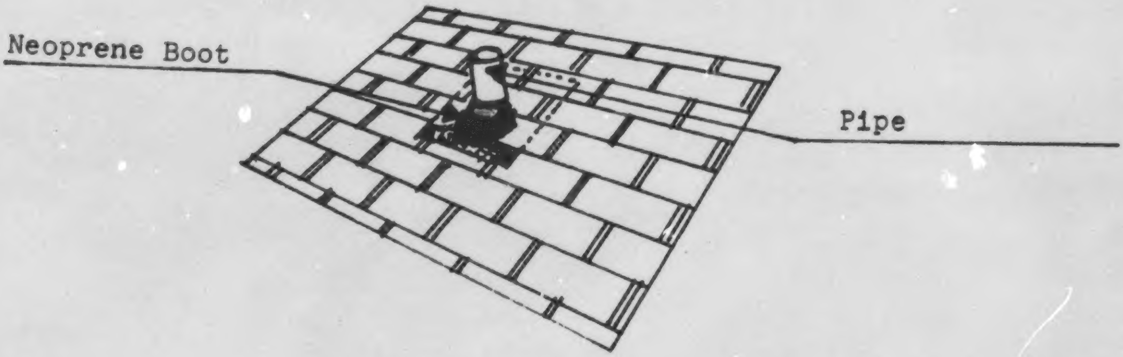
FIBERGLASS, URETHANE,
AND FOAM RUBBER
INSULATION

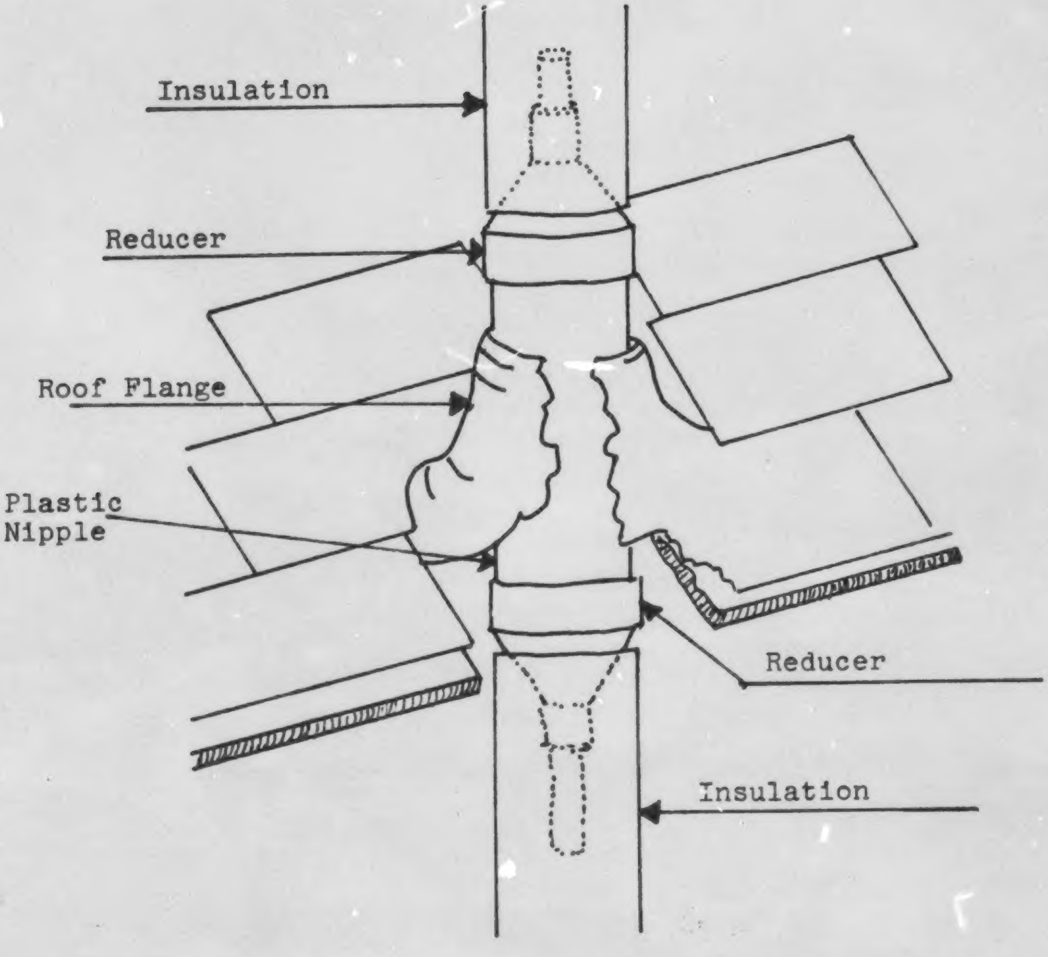
ROOF PENETRATION





ROOF PENETRATION (CONTINUED)

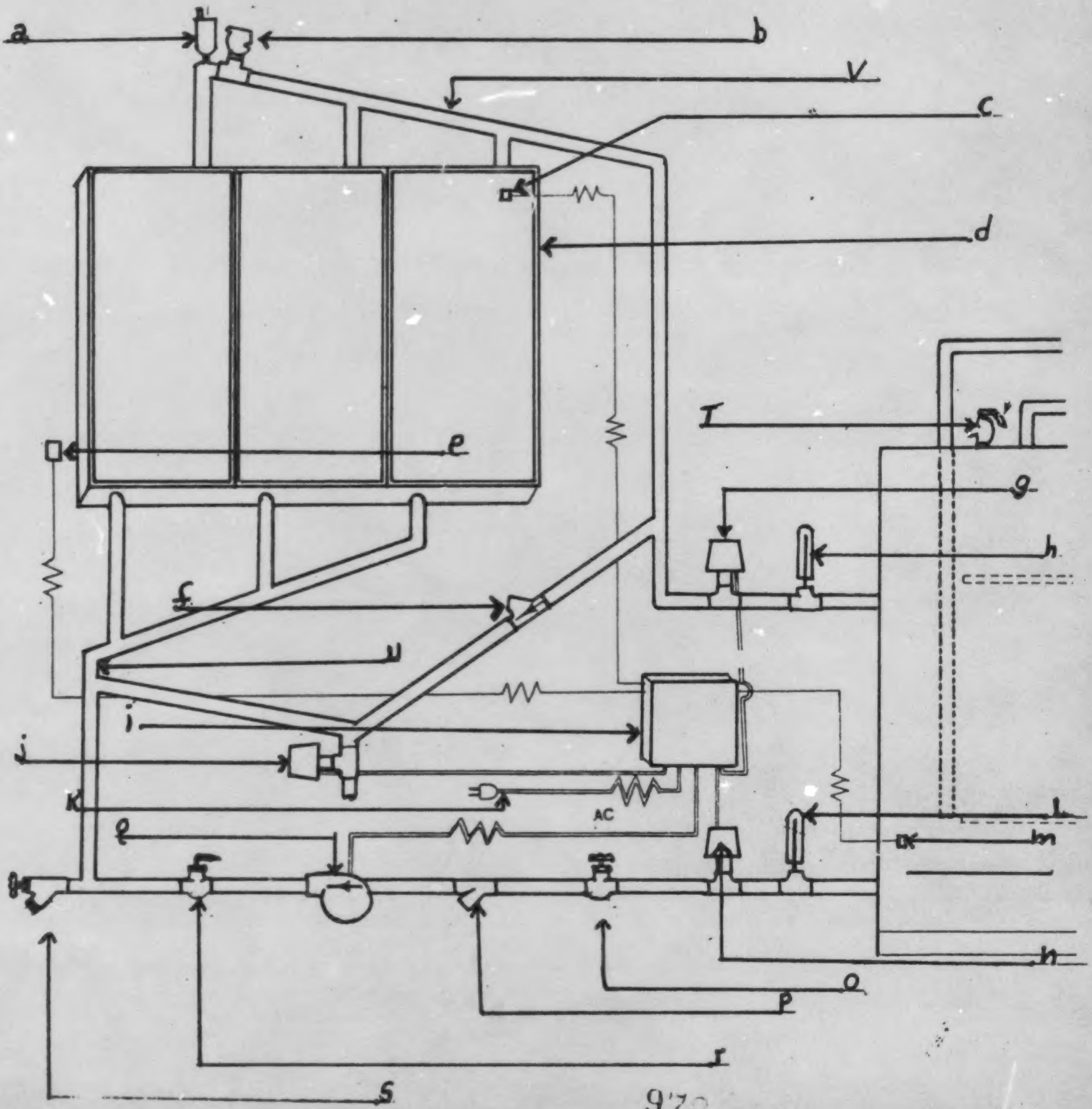




SYSTEM INSTALLATION
UNIT II

ASSIGNMENT SHEET #1--IDENTIFY COMPONENTS FROM A DIAGRAM OF A SOLAR HOTWATER SYSTEM WITH DRAIN DOWN FREEZE PROTECTION

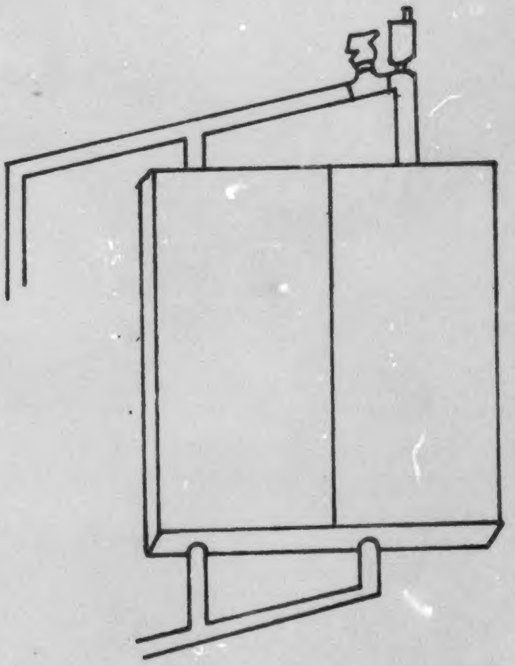
Instructions: Print the correct name of each component in the blanks provided.

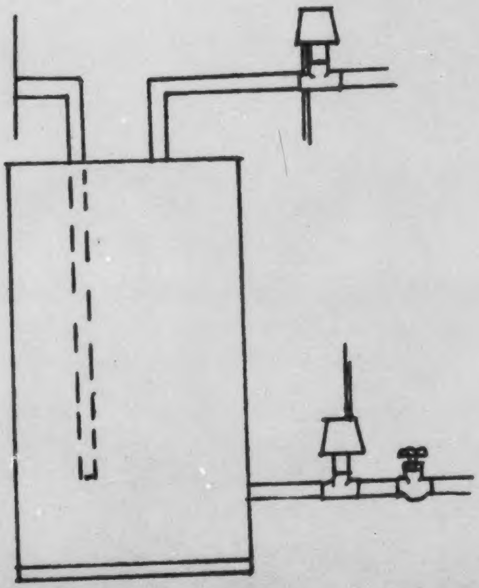


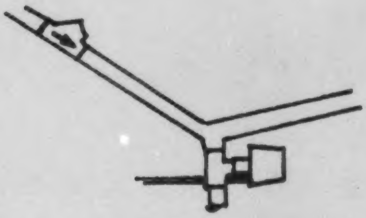
SYSTEM INSTALLATION
UNIT II

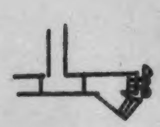
ASSIGNMENT SHEET #2--COMPLETE AN OUTLINE DIAGRAM OF A SOLAR HOTWATER SYSTEM COLLECTOR LOOP

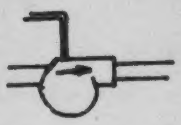
Instructions: Complete the piping installation for the components illustrated.

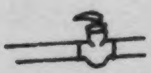


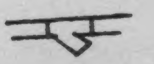












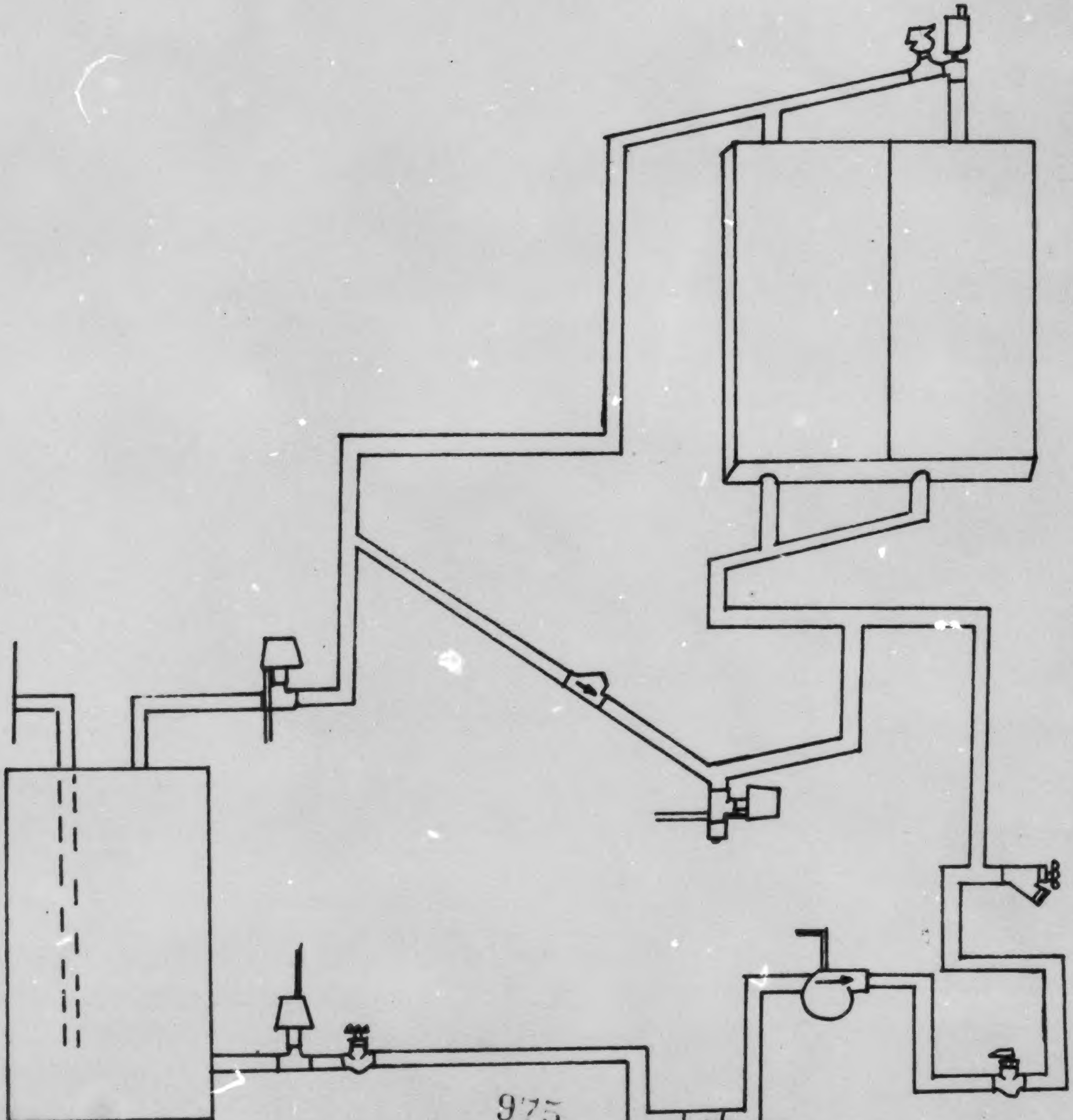
SYSTEM INSTALLATION
UNIT II

ANSWERS TO ASSIGNMENT SHEET #1

1. a. Automatic vent valve
   b. Vacuum breaker
   c. Plate sensor
   d. Flat plate collectors
   e. Frost override sensor
   f. Check valve
   g. Normally closed solenoid valve
   h. In-line thermometer
   i. Differential thermostat
   j. Three-way drain down valve
   k. 115 VAC power supply
   l. In-line thermometer
   m. Tank sensor
   n. Normally closed solenoid valve
   o. Gate valve
   p. Strainer
   q. Collector loop pump
   r. Globe valve
   s. Drain valve
   t. Pressure/temperature relief valve
   u. Inlet manifold
   v. Outlet manifold

SYSTEM INSTALLATION
UNIT II

ANSWERS TO ASSIGNMENT SHEET #2



SYSTEM INSTALLATION
UNIT II

JOB SHEET #1--INSTALL A RESIDENTIAL SOLAR HOTWATER SYSTEM WITH AUXILIARY GAS HEATER, DRAIN DOWN FREEZE PROTECTION AND FROST OVERRIDE

I. Tools, materials and components

A. Solar storage tank

B. Gas fired auxiliary heater

C. Differential thermostat with frost override circuit

D. Two flat plate collectors

E. Supply of selected size copper pipe and fittings

F. Two normally closed solenoid operated valves sized for selected copper pipe

G. Brazing torch outfit

H. Silver bearing solder and flux

I. Required mounting hardware and roof penetration fittings (if required)

J. Pipe insulation and support supplies

K. Supply of selected gas pipe and fittings

L. Vent pipe for gas heater

M. Temperature/pressure relief valves for gas heater and solar storage tank

N. Automatic air vent

O. Vacuum breaker

P. Frost cycle sensor

Q. Plate and tank sensors

R. Check valve

S. Five gate valves

T. One globe valve

U. Two thermometer wells

V. Three-way drain down valve

W. One boiler drain

X. Circulator pump

Y. In-line water strainer

Z. Mixing valve

AA. Pipe insulation cutting gauge and cutting tool

BB. Standard hand tools

CC. Pipe cutters and threaders

DD. Pipe cutting strand

EE. Pipe dope or Teflon^R tape

FF. Air gauge and manifold for pressurizing pipe for testing

GG. Liquid or electronic leak detector (for gas testing)

HH. Pipe wrenches

II. Cutting oil

JJ. Measuring tape

KK. Equipment selected by instructor to complete system installation

II. Procedures

A. Complete an outline diagram identifying location of all major components, piping, fittings, valves, mounting racks and roof penetration fittings (if used).

B. List local and/or state piping and plumbing codes that apply

C. Have the instructor evaluate A and B

Date ______________ By ____________________________

D. Complete a wiring diagram for installation of power supply to system components and all sensor wiring

E. List local/state/or National Electrical Code references that apply

F. Have the instructor evaluate D and E

Date______________ By__________________________

G. Complete a materials and supplies list covering all items needed to install the complete system

H. Check out all major components needed and place in their respected locations

I. Check out all materials, supplies, pipe, tools and equipment needed to install the solar system

J. Install the solar system as instructed

K. Have the instructor evaluate the installation

Date______________ By__________________________

L. Check out all materials, supplies, equipment and tools needed to install the gas auxiliary heater

M. Install the auxiliary heater as instructed

N. Have the instructor evaluate the installation

Date______________ By__________________________

O. Check out all materials, supplies, tools and equipment needed to install the electrical power supply and sensors

P. Complete the electrical installation

Q. Have the instructor evaluate the electrical installation

Date______________ By__________________________

R. Leak check the solar system and auxiliary heater plumbing

S. Leak check the gas heater piping

T. Have the instructor evaluate your testing procedures

Date______________ By__________________________

U. Return all unused materials and supplies to storage

V. Return all tools and equipment to their assigned location

W. Clean up your installation site

X. Have your instructor make a final overall project evaluation

Date______________ By__________________________

Y. Do not operate the system at this time.

SYSTEM INSTALLATION
UNIT II

JOB SHEET #2--CHECK OPERATION OF A DOMESTIC SOLAR HOTWATER SYSTEM WITH AUXILIARY GAS HEATER, DRAIN DOWN FREEZE PROTECTION AND FROST OVERRIDE

I. Tools and equipment

A. Temperature tester with three sensors

B. Two stem type thermometers

C. Water manometer

D. Isolation meter

E. Data collection sheet

II. Procedures

A. Check water level in both storage and auxiliary tanks

B. Install thermometers in the wells provided on the collector supply and return lines near the storage tank

C. Install a temperature sensor at the outlet of the mixing valve

D. Install a temperature sensor on the hotwater line from solar storage to auxiliary heater

E. Install a temperature sensor inside the atmosphere area of one collector plate

F. Install the water manometer and check the gas pressure delivered to the auxiliary burner; adjust (if needed) to recommended value

G. Adjust the auxiliary burner flame

H. Apply electrical power to the differential thermostat

I. Note readings of all temperature sensors and the two thermometers

J. Turn the differential thermostat to manual operation and check operation of circulator pump and two normally closed solenoid valves

K. Check for leaks in collector loop

L. Turn differential thermostat to "automatic" control

M. Record data as requested by the data sheet

N. Check operation of frost override sensor with chilled water bath

O. Continue data collection as instructed

P. Have your instructor evaluate performance

Date______________ By__________________________

SYSTEM INSTALLATION
UNIT II

JOB SHEET #3--INSTALL A CLOSED LOOP DOMESTIC SOLAR HOTWATER SYSTEM USING WATER/GLYCOL TRANSFER FLUID, REMOTE MOUNTED HEAT EXCHANGER AND STORAGE TANK WITH ELECTRIC BACKUP ELEMENT

I. Tools, materials and equipment

- A. Standard hand tools
- B. Brazing torch outfit
- C. Silver bearing solder and flux
- D. Solar storage tank with one electric element
- E. Differential thermostat
- F. Requested amount and type of copper pipe
- G. Requested number and types of valves, sensors, gauges, mounting hardware and roof jacks (if used)
- H. Requested amount and types of materials and supplies
- I. Two circulator pumps
- J. Expansion tank
- K. Back flow preventer
- L. Two flat plate collectors
- M. One remote mounted heat exchanger
- N. Container of water/glycol mixture
- O. Transfer fluid pump and connecting hoses
- P. Air eliminator
- Q. Collector supply line strainer
- R. Two thermometer wells
- S. Two stem type thermometers

T. Temperature tester with three sensors

U. Data collection sheet

II. Procedures

A. Complete an outline diagram identifying the location of all major components, piping, fittings, valves, mounting frames and roof jacks (if used)

B. List local/state piping and plumbing code articles that apply

C. Have the instructor evaluate A and B

Date______________ By_________________________

D. Complete a wiring diagram for installation of power supply to system components, electric heating element and sensor wiring

E. List all local/NEC references that apply

Date______________ By_________________________

F. Have the instructor evaluate D and E

Date______________ By_________________________

G. Complete a materials and supply list covering all items needed to install the complete solar hotwater system

H. Have the instructor evaluate your list

Date______________ By_________________________

I. Check out all major components needed and place in their respected locations

J. Check out all materials and supplies needed to install the complete system

K. Check out all tools and equipment needed to complete the installation

L. Install the solar system as instructed

M. Have the instructor evaluate the installation

Date______________ By_________________________

N. Pressure test the system piping for leaks

O. Charge the collector loop with the water/glycol mixture

P. Check and adjust the expansion tank pressure (as instructed)

Q. Check water level in the storage tank

R. Apply electrical power to the system

S. Install the two stem thermometers

T. Turn the control switch to "manual" and check operation of the circulator pumps

U. Turn the control "off" and check operation of the auxiliary heating element

V. Install a temperature sensor in the atmosphere of one collector plate

W. Install a temperature sensor on the storage tank near the tank sensor

X. Install a temperature sensor on the mixing valve outlet

Y. Turn the differential thermostat to "automatic" and check system operation

Z. Collect the required data and record

AA. Return all unused materials and supplies to storage

BB. Return all tools and equipment to their assigned areas

CC. Clean up your installation site

DD. Have your instructor make a final overall project evaluation

Date_____________ By_______________________

S-195-H

SYSTEM INSTALLATION
UNIT II

NAME______________________________

TEST

1. Match the terms on the right to their proper definition or description.

______a. A group of components designed and selected to collect, transport, store and deliver solar heated water

______b. The temperature of surrounding outside air

______c. Heat source provided by a conventional heating system when a solar system cannot meet demands

______d. The amount of heat required to raise the temperature of one pound of water one degree Fahrenheit

______e. Any part of a solar system not exposed to the atmosphere

______f. The flow of heat by contact from one area or object to another

______g. Water heating needs to be supplied by solar and/or conventional energy

______h. Pressure of the potable water within the building from sources not related to the solar hotwater system

______i. Heat exchanger with two walls between the heat transfer fluid and potable water in the system

1. Closed loop
2. Conduction
3. Open system
4. Pyranometer
5. Kilowatt hour
6. Tilt angle
7. Solar hotwater system
8. Solar pathfinder
9. Solar site selector
10. Ambient temperature
11. Auxiliary heat
12. Btu
13. Demand load
14. Stagnation temperature
15. Liquid type collector
16. Retrofitting
17. Langley

_____j. Pipe that connects the inlet and outlet risers of an array of collectors to distribute the heat transfer fluid in equal flow rates and pressure to each collector

_____k. That part of a solar system open to the atmosphere

_____l. An instrument for measuring solar radiation

_____m. The addition of a solar hotwater system to an existing hotwater unit

_____n. A measure of solar radiation equal to one calorie per square centimeter

_____o. A material with high resistance (R-value) to heat flow

_____p. A measure of power equal to one thousand watts

_____q. The amount of energy equivalent to one kilowatt of power being used for one hour equal to 3.413 Btu's

_____r. The angle that a flat plate collector surface forms with the horizontal plane

_____s. A collector in which the heat transfer fluids flow in open channels on the absorber

_____t. A collector in which the heat transfer fluid flows through metal tubes that are fastened to the absorber plate by solder, clamps, etc.

_____u. Radiation with wave lengths slightly shorter than visible light

18. Tube-in-plate collector
19. Supply water pressure
20. Header
21. Double wall heat exchanger
22. Tube type collector
23. Ultraviolet radiation
24. Insulation
25. Trickle-type collector
26. Kilowatt

_____v. An absorber plate in which the heat transfer fluid flows through passages formed in the plate itself

_____w. A device used to chart shading effects when selecting placement and orientation of collectors

_____x. Visual solar calcuator and site selector device that determines solar access

_____y. A collector using a liquid as the heat transfer fluid

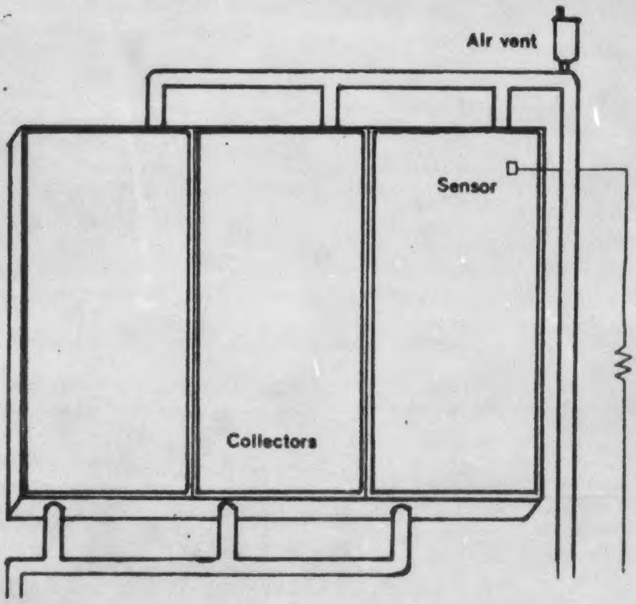
_____z. High temperature that results when fluids or gases in a non-moving or stagnation condition are exposed to solar heat gain for extended periods of time

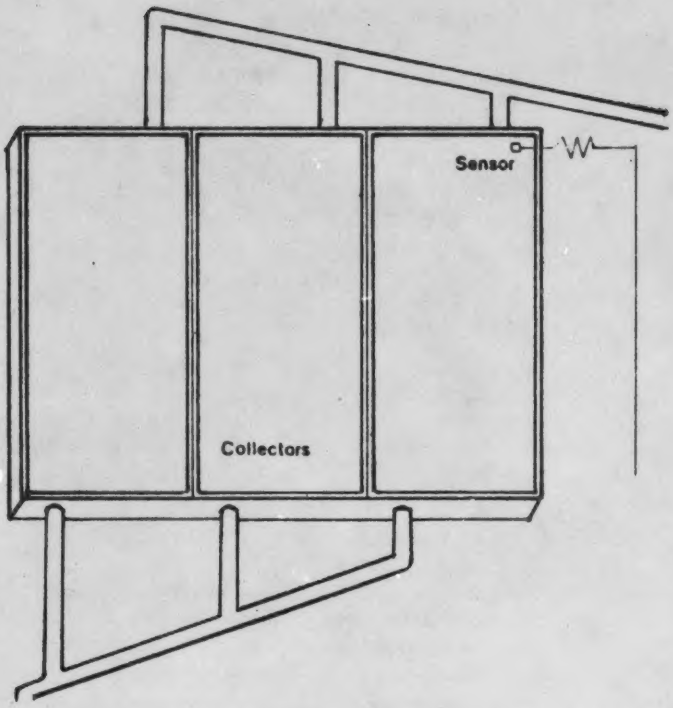
2. Identify four common types of domestic solar hotwater systems from collector array or storage tank outline.

a. ____________________

____

____

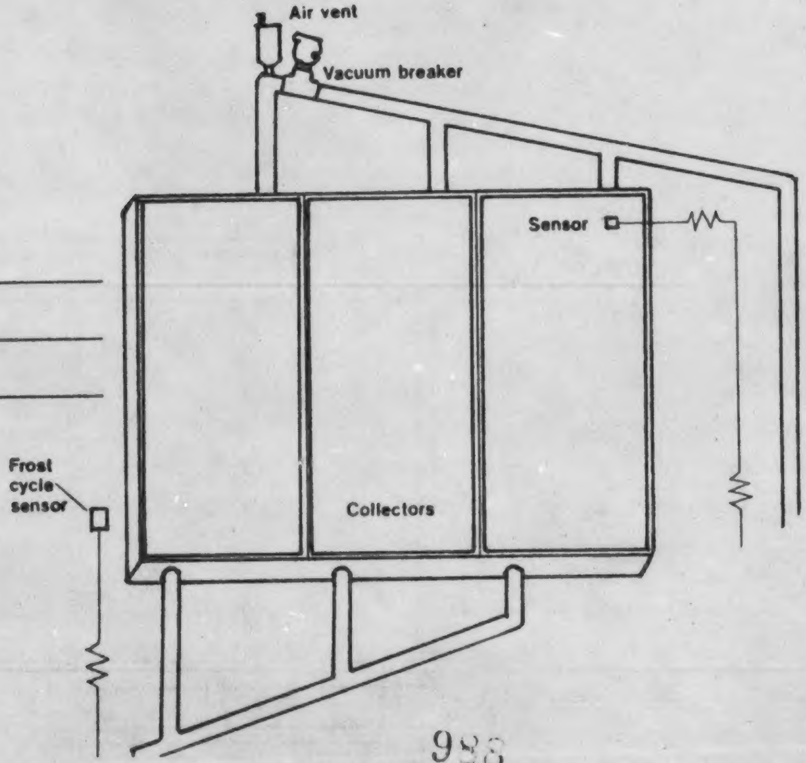



Sensor
Collectors

b. ____________

____

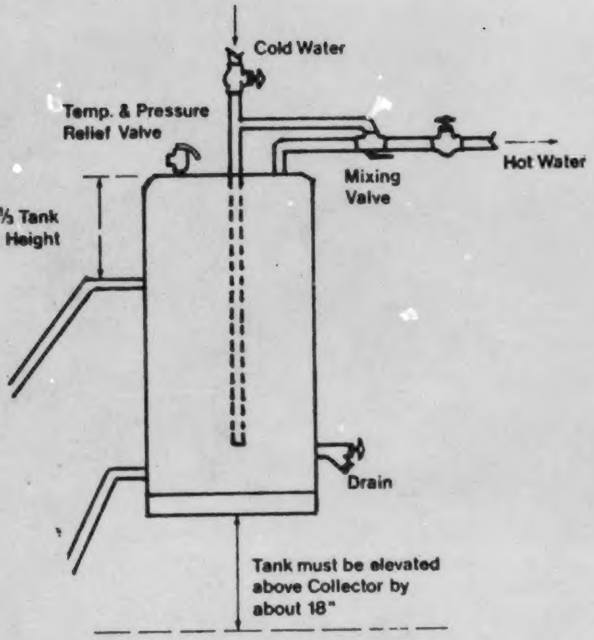
____


Air vent
Vacuum breaker
Sensor
Frost cycle sensor
Collectors

c. ____________

____

____


Cold Water
Temp. & Pressure Relief Valve
Mixing Valve
Hot Water
⅓ Tank Height
Drain
Tank must be elevated above Collector by about 18"

d. ____________________

____

3. Match items on the right to their correct installation procedures for a solar DHW system using an electric backup heater.

(NOTE: Items on the right may be used more than once.)

a. Major components location diagram	1. Supplies
____1) ____5)	2. Storage tank
____2) ____6)	3. Circulator pumps
____3) ____7)	4. System controls
____4)	5. Collectors
b. Piping diagram	6. Auxiliary heater
____1)	7. Materials
____2)	

c. Electrical diagram

_____1)

_____2)

_____3)

_____4)

d. Materials and supplies list

_____1)

_____2)

8. Components

9. Valves and fittings

10. Differential temperature control

11. Expansion tank

12. Remote mounted heat exchanger

4. List seven methods for mounting flat plate collectors and circle the one recommended for flat roofs.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

5. Select the recommended ± variation for orientation of flat plate collectors from the list on the right and list the recommended tilt above the horizon for maximum winter output.

_____a. Orientation variation

_____b. Recommended tilt

1. ± 8°

2. ± 12° to 15°

3. ± 33°

4. ± 15°

5. ± 17° to 20°

6. List four applications for silicone flexible connectors.

a. ____

b. ____

c. ____

d. ____

7. Match statements on the right to their correct application on hanging and supporting steel, copper and plastic pipe.

a. Copper pipe

___1) Vertical runs

Horizontal runs

___2) Hard copper

___3) Soft copper

b. Threaded steel pipe

___1) Vertical runs

___2) Horizontal runs

c. Rigid plastic pipe

___1) Vertical runs

___2) Horizontal runs

1. Support at five foot intervals
2. Support at twenty foot intervals
3. Support at one-to-two foot intervals
4. Eight foot intervals for hard copper
5. Support at twelve foot intervals
6. Six foot intervals for annealed copper
7. Support at ten foot intervals

8. Match R-values on the right to their correct insulation types.

___a. Fiberglass insulation

___b. Elastomers

___c. Urethane

1. R-5 per inch
2. R-3.2 per inch
3. R-3 per inch
4. R-3.5 per inch
5. R-6.5 per inch
6. R-5.5 per inch

9. Select from the list on the right the two types of solenoid valves used in a drain down system.

___a.	Collector drain line	1.	Normally open valve
___b.	Collector circulation lines	2.	Normally closed valve
		3.	Two-way normally closed valve
		4.	Three-way normally open valve
		5.	Three-way normally closed valve
		6.	Two-way normally open valve

10. Discuss the applications of three voltage values common to demestic solar systems and electric backup heaters.

a. 115 volts

1) ______________________________

____

2) ______________________________

3) ______________________________

4) ______________________________

____

b. 24 volts

1) ______________________________

____

2) ______________________________

____

c. 230 volts

1) ______________________________

____

____

2) ______________________________

____

3) ______________________________

____

11. Match the statements on the right to their correct application on proper use of ropes and list five rules for care of ropes.

a. Knots and hitches

___1) Figure eight knot

___2) Square knot

___3) Bowline

___4) Timber hitch

___5) Clove hitch

___6) Sheet bend

1. Used to hold pipe and frame members in place for assembling, etc.

2. Used to join ropes together or to attach a rope to an eye hook

3. Used in the end of a rope to temporarily prevent the strands from unlaying

4. Used to join two ropes or lines of the same size

5. Is easily constructed and used whenever a loop is required that will not slip, jam or fail

6. Very useful for hoisting boards, pipe or other objects requiring a knot that will not slip or jam

b. Care of ropes

1) ________________________________

2) ________________________________

3) ________________________________

____

4) ________________________________

____

5) ________________________________

12. List three methods of roof penetration with a shingled roof.

a. ____________________________________

b. ____________________________________

c. ____________________________________

13. Match statements on the right to their proper application on recommended types of pipe for a solar system and list five methods of connecting copper pipe in a solar system.

a. Copper pipe

___1) Type L hard copper

___2) Type L soft copper

___3) Type M hard copper

b. Plastic pipe

___1) PVC pipe

___2) CPVC pipe

c. Galvanized threaded pipe

___1)

___2)

1. Available in twenty-one foot lengths

2. Recommended for cold water use only

3. Available in twenty foot lengths

4. Available in coils of 25', 50' and 60' lengths

5. Recommended for hot and/or cold water service for special applications

6. Is rated for hot water use to about 180°F, but will require careful support is used in the collector loop

7. Available in twenty foot lengths

d. Methods of connecting

1) Copper pipe

a) ____

____

b) ____

____

c) ____

____

d) ____

____

e) ____

____

14. Match statements on the right to their proper application on safety.

a. Electrical

___1)

___2)

b. Maintenance personnel safety

___1)

1. A tempering valve should be installed on each hotwater system to control the temperature of water directed to the use points to prevent possible scalding

c. Predestrian and visitor safety

___1)

___2)

___3)

d. Heat transfer fluid safety

___1)

___2)

___3)

___4)

___5)

___6)

e. User safety

___1)

___2)

2. A double wall heat exchanger is required with all systems using a toxic heat transfer fluid

3. Must meet local code requirements

4. Ends of pipes draining heat transfer fluids should not be threaded

5. All surfaces with operating temperatures above 120°F that cannot be insulated should be marked as potential hazards to prevent burns

6. The system controller should have its own properly grounded and protected power circuit

7. Components should be located so as to insure safe, easy access to all major components

8. There should be an air gap of at least six inches between the ends of all piping used to drain toxic fluids and the drain point

9. All temperature and/or pressure relief valves should be located to vent into a safe area

10. All outlets and faucets on non-portable water should be wired closed or locked and tagged "Danger-Not Drinkable"

11. All piping exposed to possible contact by individuals on the ground should be supported well enough to prevent damage by carelessness or children

12. The vaccuum relief valves required to prevent the possible collapse of storage or expansion tanks must not be allowed to freeze.

13. Should be discharged into dry well storage or sanitary drain in a manner acceptable to local codes

14. A harmless dye should be added to all toxic or nonpotable heat transfer fluids

15. Demonstrate the ability to:

    a. Identify components from a diagram of a solar hot-water system with drain down freeze protection.

    b. Complete an outline diagram of a solar hotwater system collector loop.

    c. Install a residential solar hotwater system with auxiliary gas heater, drain down freeze protection and frost override.

    d. Check operation of a domestic solar hotwater system with auxilary gas heater, drain down freeze protection and frost override.

e. Install a closed loop domestic solar hot-water system using water/glycol transfer fluid, remote mounted heat exchanger and storage tank with electric backup element.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

S-209-H

SYSTEM INSTALLATION
UNIT II

ANSWERS TO TEST

1.	a.	7	j.	20	s.	25
	b.	10	k.	3	t.	22
	c.	11	l.	4	u.	23
	d.	12	m.	16	v.	18
	e.	1	n.	17	w.	8
	f.	2	o.	24	x.	9
	g.	13	p.	26	y.	15
	h.	19	q.	5	z.	14
	i.	21	r.	6		

2. a. Closed loop system
   b. Drain back system
   c. Drain down system
   d. Thermosphion system

3. a. Major components location diagram

1)	5	5)	12
2)	2	6)	3
3)	6	7)	10
4)	11		

   b. Piping diagram

1)	8
2)	9

   c. Electrical diagram

1)	2	3)	6
2)	4	4)	3

d. Materials and supplies list

1) 7

2) 1

4. a. Spanner mounted in open attic

b. Spanner mounted with concealed attic

c. Lag bolt mounted

d. Rack mounted

e. Pipe mounted

f. Brackey mounted

[✓ g.] Upright mounted (recommended for flat roofs)

5. a. 4

b. 2

6. Any arrangement of the following four:

a. Connecting collectors end to end

b. Connecting collectors to piping manifolds

c. As expansion joints

d. Connecting dissimilar metal piping

7. a. Copper pipe

1) 7

2) 4

3) 6

b. Threaded steel pipe

1) 2

2) 5

c. Rigid plastic pipe

1) 1

2) 3

8. a. 3
   b. 4
   c. 5

9. a. 4
   b. 2

10. a. 115 volts - Any arrangement of the following statements

    1) Operates the input side of most differential temperature controls

    2) Operates the circulator pumps

    3) Operates most solenoid operated valves

    4) Operates the power "on" indicator bulbs on many controls

    b. 24 volts - Any arrangement of the following statements

    1) Operates the output side of most differential temperature control relays

    2) Operates the circuits "on" indicator bulbs on some differential thermostats

    c. 230 bolts - Any arrangement of the following statements

    1) Used to operate the electric elements on solar storage tanks equipped with backup electric elements

    2) Used to operate the electric elements on electric auxiliary heaters

    3) Used to operate some circulator pump motors

11. a. 1) 3 4) 6
       2) 4 5) 1
       3) 5 6) 2

b. Any five of the following:

1) Avoid overloading

2) Avoid kinks and sharp angles

3) Avoid chemical contacts with rope

4) Avoid prolonged exposure to direct sunlight

5) Keep rope clean

6) Use proper size pulleys

12. Any arrangement of the following:

a. Copper flashing and pipe stub

b. Neoprene boot and flange

c. Reducers and plastic nipple method

13. a. 1) 3 or 7

2) 4

3) 7 or 3

b. 1) 2

2) 6

c. 1) 1

2) 5

d. Any five of the following:

1) Sweat joints made with 95-5 tin antimony solder and non-acid flux

2) Threaded joints using Teflon^{R} tape

3) Threaded joints using a quality compound such as Loctite^{R}

4) Sweat joints made with silver solder

5) Sweat joints made with a silver-bearing solder

6) Sweat joints made with brazing alloys

14. a. 1) 3
    2) 6
  b. 1) 7
  c. 1) 5
    2) 9
    3) 11
  d. 1) 13
    2) 14
    3) 10
    4) 4
    5) 8
    6) 2
  e. 1) 1
    2) 12

15. Evaluated to the satisfaction of the instructor

SPECIFIC SAFETY
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to list specific safety rules pertaining to the air-conditioning trade. The student should also be able to match ampere figures to their effects on the human body, discuss rescue procedures, and identify color coding on safety signs or tags. This knowledge will be evidenced by scoring one-hundred percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with safety to the correct definitions or descriptions.
2. List the six classifications of accidents in the shop.
3. List ten electrical safety rules.
4. List ten refrigerant related safety rules.
5. List the seven highly flammable gases used in this trade.
6. List four safety rules for using the air-acetylene torch.
7. List five safety rules for charging or discharging fluorinated hydrocarbon refrigerants.
8. List three safety rules for pressurizing a system.
9. List eight safety rules for handling refrigerant cylinders.
10. List the two major causes of electrical accidents.
11. List six safety rules for using electrical tools.
12. Match ampere figures to their effects on the human body.

13. Discuss rescue procedures in case of electrical accidents.

14. Identify color coding on safety tags or signs.

SPECIFIC SAFETY
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet.
- B. Provide student with information sheet.
- C. Make transparencies.
- D. Discuss unit and specific objectives.
- E. Discuss information sheet.
- F. Invite resource people to talk to class.

  Examples: Electric company representative or an air-conditioning contractor

- G. Have students simulate an accident and the proper procedure for handling.
- H. Give test.

II. Student:

- A. Read objective sheet.
- B. Study information sheet.
- C. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Transparency masters
  - 1. TM 1--Rescue Procedure
  - 2. TM 2--"Do Not Start" Tag

        3. TM 3--"Danger" Tag
        4. TM 4--"Caution" Tag
        5. TM 5--"Out of Order" Tag
    D. Test
    E. Answers to test

II. References:

A. Lieberman, Eli. "Be Aware of Electrical Safety." Refrigeration Service and Contracting, July 1971.

B. Federal Register 37: 22239-22242, October 18, 1972.

C. Downing, R. C. Refrigerants and Service Pointer Manual. Wilmington, Delaware: Freon Products Division/E. I. Dupont DeNemours and Co., 1970.

SPECIFIC SAFETY
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Specific safety rules--Safety rules that pertain to a particular trade or operation

B. Hydrostatic pressure--Pressure created in a vessel by overfilling, which could result in the vessel exploding

C. Fluorinated hydrocarbons--Group of refrigerants which are nontoxic, nonflammable, nonexplosive, and noncorrosive

D. Tag--Safety sign that can be affixed to a particular piece of equipment

E. Ampere--Unit of electrical current flow

(NOTE: A milliampere would be one thousandth of an ampere. The abbreviation for ampere is amp.)

F. Toxic--Poisonous

II. Classifications of accidents in the refrigeration shop

A. Injuries due to mechanical causes

B. Injuries due to electrical shocks

C. Injuries due to high pressure

D. Injuries due to burns and scalds

E. Injuries due to explosions

F. Injuries due to breathing toxic gas

III. Electrical safety rules

A. Do not underestimate the potential danger of a 110 VAC circuit

B. Be careful around electric arcs because they can cause bad burns to skin and eyes

C. Remember that the involuntary reaction to electric shock can cause you to injure yourself and possibly others

D. Work on live circuits only when absolutely necessary

E. Refuse to install equipment that will overload a circuit

F. Never bypass an electrical protective device

G. Properly fuse all electrical lines

H. Cover all electrical wires with conduit before running them over refrigerant piping

I. Properly insulate all electrical wiring

J. Stand on dry nonconductive surfaces when working on live circuits

K. Check all circuits for voltage before doing any service work

L. Tag and lock all electrical disconnects when working on live circuits

IV. Refrigerant related safety rules

A. Ventilate a gas filled room before entering

B. Do not overfill a container because this may cause an explosion

C. Do not pump liquid refrigerant in a compressor because this may cause the compressor to explode

D. Never refill a disposable refrigerant cylinder

E. Never put a flame on a refrigerant cylinder

F. Be careful of acids created in a system due to moisture or compressor burnout

G. Never apply a torch to a pressurized system

(NOTE: An exception to this rule is when it is necessary to solder some types of service valves onto the outside of a line while there is pressure in the system.)

H. Do not use refrigerant lines as supports

I. Inspect refrigerant line flares before using

J. Inspect all pressure gauge hoses and connections before using

K. Wear safety glasses when working with refrigerants

L. Never warm a refrigerant cylinder above 125°F

M. Back seat valve stems before removing gauge port caps

N. Never use carbon tetrachloride as a cleaning solvent because it is extremely toxic

O. Use naptha with a high flash point of 100°F or more for cleaning

P. Fluorinated hydrocarbons are nontoxic in moderate amounts unless in the presence of a flame or high temperature surface

Q. Do not inhale refrigerants

R. Always remove the door from discarded refrigerators

S. Never discharge compressed gases toward any person

V. Highly flammable gases used in the trade

A. Propane

B. Propylene

C. Ethane

D. Ethylene

E. Methane

F. Isobutane

G. Acetylene

VI. Safety rules for using the air-acetylene torch

A. Always use a regulator

B. Wear colored safety glasses

C. Light torch with striker

D. Open cylinder only one-quarter of a turn

E. Always set cylinder up against something to prevent it from being accidently knocked over

F. Do not use a torch on a pressurized system

(NOTE: Air-acetylene torches are commonly referred to as prestolite torches.)

VII. Safety rules for charging or discharging fluorinated hydrocarbon refrigerants

A. Be aware that any gas under pressure can be hazardous

B. Do not refill disposable refrigerant cylinders

C. Have adequate ventilation when purging refrigerants

D. Do not discharge fluorinated hydrocarbon refrigerants into an open flame because this will create harmful phosgene gas

E. Never spray liquid refrigerant directly on the skin because this will cause a bad burn

(NOTE: If liquid refrigerant is sprayed directly on the skin or in the eyes, flush the area with cold water and get treatment.)

F. Never apply a torch to a refrigerant cylinder

G. Use a cloth around the hose fittings when removing them from a pressurized system or cylinder

VIII. Safety rules for pressurizing a refrigeration system

A. Never use oxygen or acetylene to pressurize a system

(NOTE: Oxygen will explode on contact with oil. Acetylene will explode under pressure unless dissolved in acetone.)

B. Never use dry nitrogen without a regulator

(NOTE: Nitrogen cylinders contain pressure in excess of 2000 pounds per square inch (p.s.i.)

C. Never apply heat to a pressurized cylinder which could cause a rise in pressure resulting in an explosion

D. Never pressurize refrigerant systems over 150 pounds per square inch gauge (p.s.i.g.) during a leak test

IX. Safety rules for handling refrigerant cylinders

A. Do not drop cylinders

B. Do not refill disposable refrigerant cylinders

C. Do not heat cylinders with a torch

D. Secure cylinders in a moving vehicle

E. Do not spray refrigerant on skin

F. Do not inhale refrigerant

G. Do not spray refrigerant into open flame

H. Do not mix refrigerants

I. Replace cylinder cap when not in use to protect valve

J. Do not lift or carry cylinder by valve

K. Secure large cylinders to wall or bench

L. Have adequate ventilation

M. Remove valve or puncture cylinder when discarding disposable refrigerant cylinders

X. Major causes of electrical accidents

- A. Carelessness
- B. Misuse

XI. Safety rules for using electrical tools

- A. Have a ground on all power tools
- B. Use proper size electrical cord
- C. Have proper guards on all tools
- D. Do not use tools with frayed or damaged cords
- E. Stand on dry nonconductive surfaces when using electrical tools
- F. Wear eye protection

XII. Amperes and their effects on the human body

(NOTE: Current is in milliamperes. One ampere is equal to 1,000 milliamperes.)

- A. Less than .5 milliamps--No sensation
- B. 2 to 10 milliamps--Muscular contraction
- C. 5 to 25 milliamps--Painful shock, inability to let go
- D. Over 25 milliamps--Violent muscular contraction
- E. 50 to 200 milliamps--Heart convulsions, death
- F. Over 100 milliamps--Paralysis of breathing, burns

XIII. Rescue procedure in electrical accidents (Transparency 1)

- A. Locate live wire and disconnect if possible
- B. Decide if it would be easier to move the person or the conductor

(CAUTION: If conductor is to be moved use dry limb or some other nonconductive device; if the individual is to be moved use several thicknesses of paper or cloth as an insulator. Do not take hold of person with your bare hand.)

C. Separate victim and conductor

XIV. Color coding of safety tags or signs

A. "Do not start" tag or sign (Transparency 2)

1. White tag or sign

2. White letters on red square

B. "Danger" tag or sign (Transparency 3)

1. White tag or sign

2. White letters on red oval with a black square

C. "Caution" tag or sign (Transparency 4)

1. Yellow tag or sign

2. Yellow letters on black square

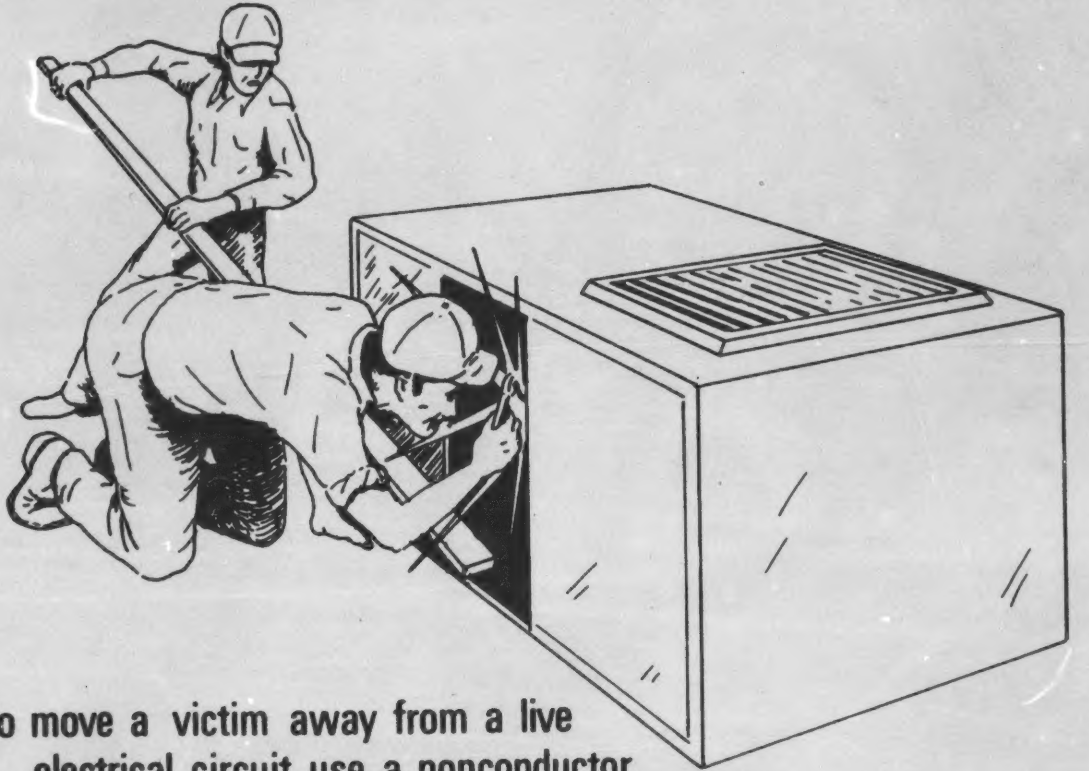
D. "Out of order" tag or sign (Transparency 5)

1. White tag or sign

2. White letters on black square

(NOTE: The color coding for a permanent sign is the same as that for a tag.)

Rescue Procedure

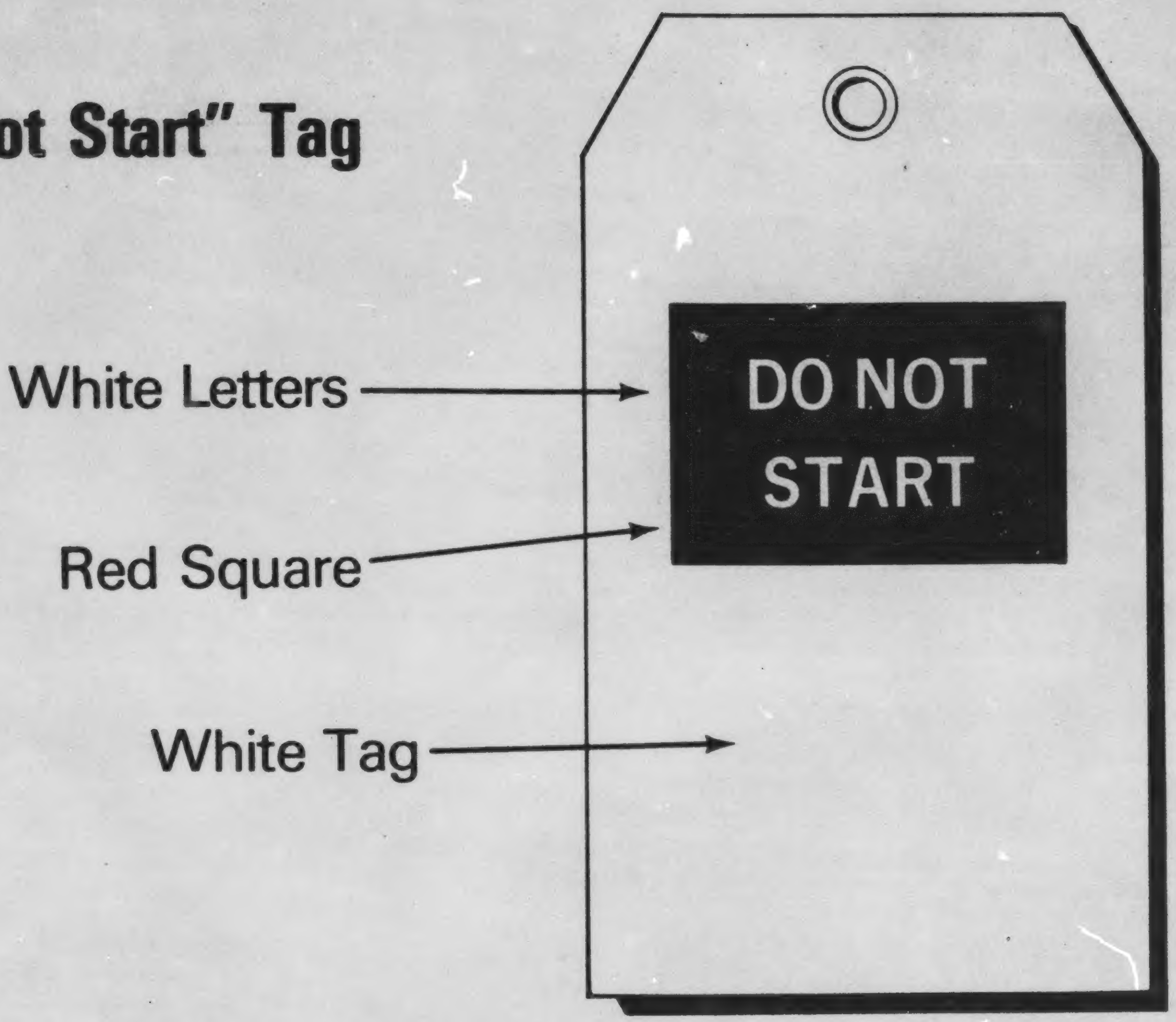


To move a victim away from a live electrical circuit use a nonconductor such as a long dry wooden or plastic pole or a very dry tree branch.

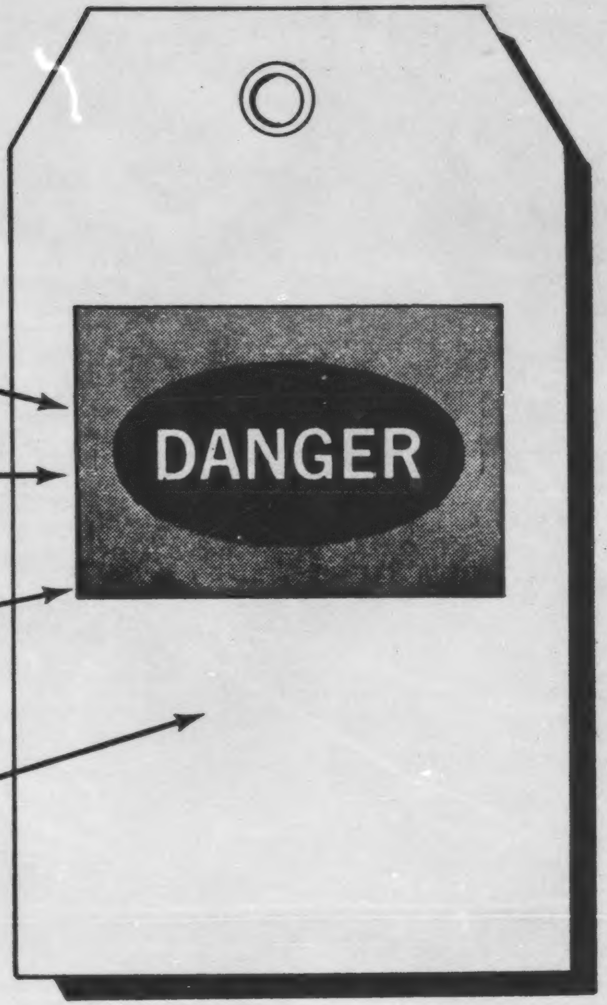
1015

1016

"Do Not Start" Tag



"Danger" Tag



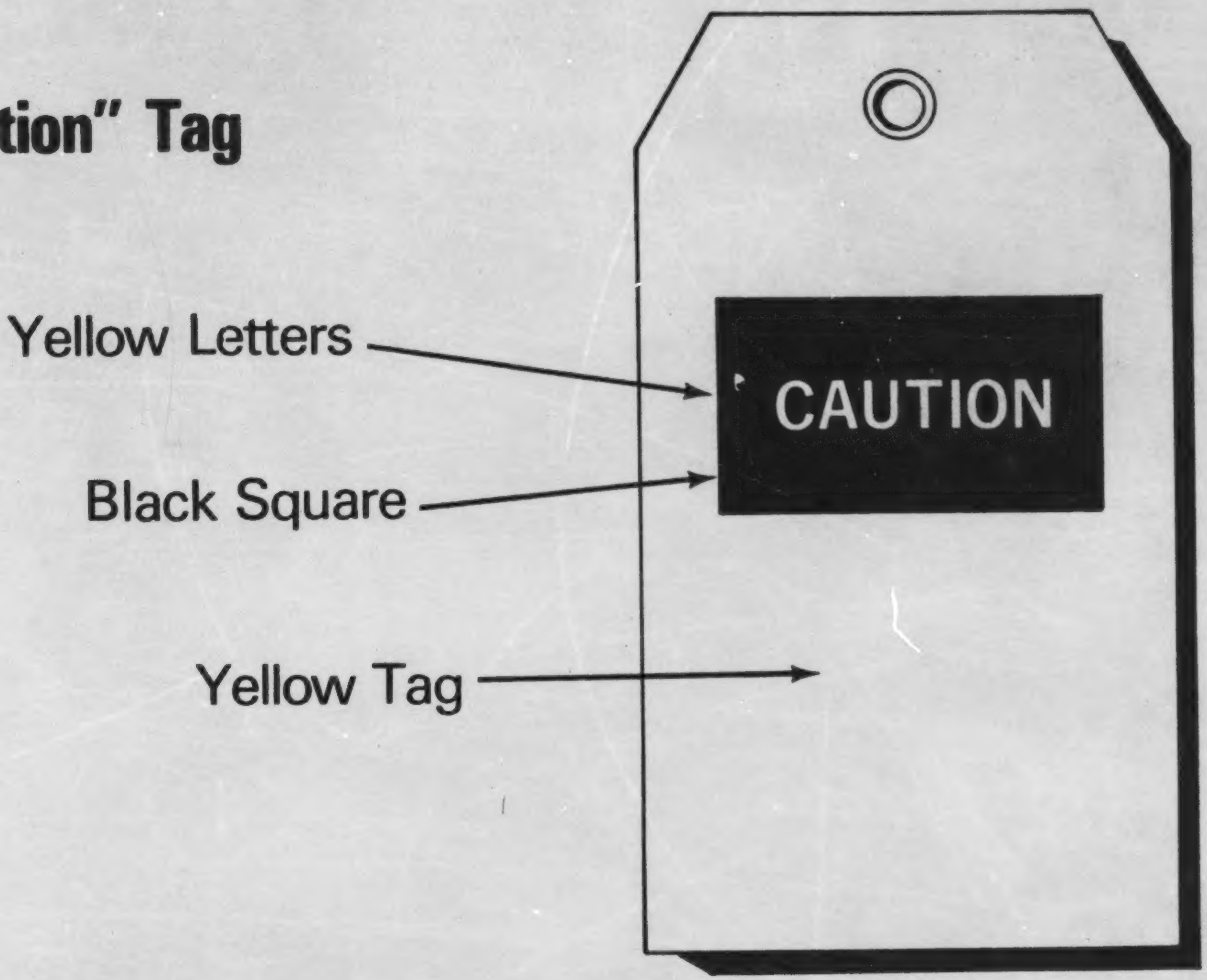
White Letters

Red Oval

Black Square

White Tag

"Caution" Tag

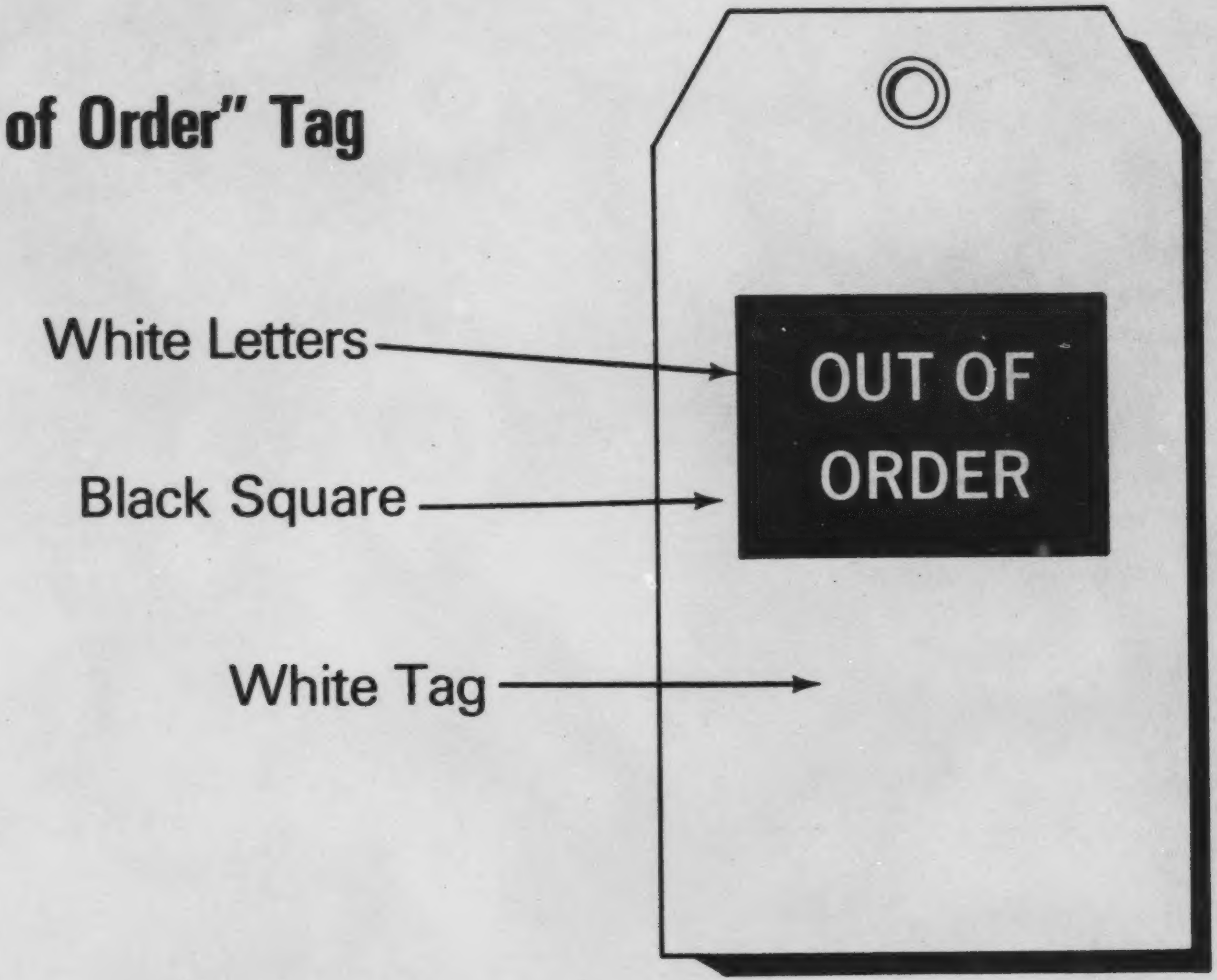


Yellow Letters

Black Square

Yellow Tag

"Out of Order" Tag



White Letters

Black Square

White Tag

SPECIFIC SAFETY
UNIT I

NAME____________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Unit of electrical current flow

_____b. Group of refrigerants which are nontoxic, nonflammable, nonexplosive, and noncorrosive

_____c. Poisonous

_____d. Pressure created in a vessel by overfilling, which could result in the vessel exploding

_____e. Safety sign that can be affixed to a particular piece of equipment

_____f. Safety rules that pertain to a particular trade or operation

1. Toxic
2. Tag
3. Fluorinated hydrocarbons
4. Specific safety rules
5. Hydrostatic pressure
6. Ampere

2. List the six classifications of accidents in the shop.

a.____

b.____

c.____

d.____

e.____

f.____

3. List ten electrical safety rules.

a.____

b. ____

c. ____

d. ____

e. ____

f. ____

g. ____

h. ____

i. ____

j. ____

4. List ten refrigerant related safety rules.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

g. ____

h. ____

i. ____

j. ____

5. List the seven highly flammable gases used in this trade.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________

6. List four safety rules for using the air-acetylene torch.

a. ____

b. ____

c. ____

d. ____

7. List five safety rules for charging or discharging fluorinated hydrocarbon refrigerants.

a. ____

____

b. ____

____

c. ____

____

d. ____

____

e. ____

____

8. List three safety rules for pressurizing a system.

a. ____

____

b. ____

____

c. ____

____

9. List eight safety rules for handling refrigerant cylinders.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

g. ____

h. ____

10. List the two major causes of electrical accidents.

a. ______________________

b. ______________________

11. List six safety rules for using electrical tools.

a. ____

b. ____

c. ____

d. ____

e. ____

f. ____

12. Match the ampere figures on the right to their effects on the human body.

_____a. Painful shock, inability to let go

_____b. Violent muscular contraction

_____c. Heart convulsions, death

_____d. No sensation

_____e. Muscular contraction

_____f. Paralysis of breathing, burns

1. Over 25 milliamps
2. 5 to 25 milliamps
3. Over 100 milliamps
4. Less than .5 milliamps
5. 2 to 10 milliamps
6. 50 to 200 milliamps

13. Discuss the rescue procedure in case of electrical accidents.

14. Identify color coding on safety tags or signs.

SPECIFIC SAFETY
UNIT I

ANSWERS TO TEST

1.	a. 6	d. 5
	b. 3	e. 2
	c. 1	f. 4

2.
 a. Injuries due to mechanical causes
 b. Injuries due to electrical shocks
 c. Injuries due to high pressure
 d. Injuries due to burns and scalds
 e. Injuries due to explosions
 f. Injuries due to breathing toxic gases

3. Any ten of the following:
 a. Do not underestimate the potential danger of a 110 VAC circuit
 b. Be careful around electric arcs because they can cause bad burns to skin and eyes
 c. Remember that the involuntary reaction to electric shock can cause you to injure yourself and possibly others
 d. Work on live circuits only when absolutely necessary
 e. Refuse to install equipment that will overload a circuit
 f. Never bypass an electrical protective device
 g. Properly fuse all electrical lines
 h. Cover all electrical wires with conduit before running them over refrigerant tubing
 i. Properly insulate all electrical wiring

j. Stand on dry nonconductive surfaces when working on live circuits

k. Check all circuits for voltage before doing any service work

l. Tag and lock all electrical disconnects when working on live circuits

4. Any ten of the following:

a. Ventilate a gas filled room before entering

b. Do not overfill a container because this may cause an explosion

c. Do not pump liquid refrigerant in a compressor because this may cause the compressor to explode

d. Never refill a disposable refrigerant cylinder

e. Never put a flame on a refrigerant cylinder

f. Be careful of acids created in a refrigeration system due to moisture or compressor burnout

g. Never apply a torch to a pressurized system

h. Do not use refrigerant lines as supports

i. Inspect refrigerant line flares before using

j. Inspect all pressure gauge hoses and connections before using

k. Wear safety glasses when working with refrigerants

l. Never warm a refrigerant cylinder above 125°F

m. Back seat valve stems before removing gauge port caps

n. Never use carbon tetrachloride as a cleaning solvent because it is extremely toxic

o. Use naptha with a high flash point of 100°F or more for cleaning

p. Fluorinated hydrocarbons are nontoxic in moderate amounts unless in the presence of a flame or high temperature surface

q. Do not inhale refrigerants

r. Always remove the door from discarded refrigerators

s. Never discharge compressed gases toward any person

5. a. Propane

b. Propylene

c. Ethane

d. Ethylene

e. Methane

f. Isobutane

g. Acetylene

6. Any four of the following:

a. Always use a regulator

b. Wear colored safety glasses

c. Light torch with striker

d. Open cylinder only one-quarter of a turn

e. Always set cylinder up against something to prevent it from being accidently knocked over

f. Do not use a torch on a pressurized system

7. Any five of the following:

a. Be aware that any gas under pressure can be hazardous

b. Do not refill disposable refrigerant cylinders

c. Have adequate ventilation when purging refrigerants

d. Do not discharge fluorinated hydrocarbon refrigerants into an open flame because this will create harmful phosgene gas

e. Never spray liquid refrigerant directly on the skin because this will cause a bad burn

  f. Never apply a torch to a refrigerant cylinder

  g. Use a cloth around the hose fittings when removing them from a pressurized system or cylinder

8. Any three of the following:

  a. Never use oxygen or acetylene to pressurize a system

  b. Never use dry nitrogen without a regulator

  c. Never apply heat to a pressurized cylinder which could cause a rise in pressure resulting in an explosion

  d. Never pressurize refrigerant systems over 150 pounds per square inch gauge (p.s.i.g.) during a leak test

9. Any eight of the following:

  a. Do not drop cylinders

  b. Do not refill disposable refrigerant cylinders

  c. Do not heat cylinders with a torch

  d. Secure cylinders in a moving vehicle

  e. Do not spray refrigerant on skin

  f. Do not inhale refrigerant

  g. Do not spray refrigerant into open flame

  h. Do not mix refrigerants

  i. Replace cylinder cap when not in use to protect valve

  j. Do not lift or carry cylinder by valve

  k. Secure large cylinders to wall or bench

  l. Have adequate ventilation

  m. Remove valve or puncture cylinder when discarding disposable refrigerant cylinders

10. a. Carelessness
    b. Misuse

11. a. Have a ground on all power tools
    b. Use proper size electrical cord
    c. Have proper guards on all tools
    d. Do not use tools with frayed or damaged cords
    e. Stand on dry nonconductive surfaces when using electrical tools
    f. Wear eye protection

12. a. 2
    b. 1
    c. 6
    d. 4
    e. 5
    f. 3

13. Discussion should include:
    a. Locate live wire and disconnect if possible
    b. Decide if it would be easier to move the person or the conductor
    c. Separate victim and conductor

14. a. 1) White tag
       2) White letters
       3) Red square
    b. 1) Red oval
       2) White tag
       3) White letters
       4) Black square
    c. 1) Yellow tag
       2) Yellow letters
       3) Black square

d. 1) White tag
   2) White letters
   3) Black square

SPECIAL TOOLS
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify, use, and care for the specialized tools used in the air-conditioning and solar trades. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with specialized tools to the correct definitions.
2. Identify specialized tools.
3. Describe the use of the specialized tools.
4. Describe the care of the specialized tools.
5. Identify the components of the refrigeration gauge set
6. List when each refrigeration gauage set component is used.

SPECIAL TOOLS
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Demonstrate and discuss the procedure outlined in the job sheet.

  G. Show students special tools.

  H. Take field trip to a parts wholesaler.

  I. Have students look up tools in catalogs to get an idea of the cost involved in equipping a shop.

  J. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete activities assigned by instructor.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Special Tools

2. TM 2--Special Tools (Continued)
3. TM 3--Special Tools (Continued)
4. TM 4--Special Tools (Continued)
5. TM 5--Special Tools (Continued)
6. TM 6--Special Tools (Continued)
7. TM 7--Special Tools (Continued)
8. TM 8--Special Tools (Continued)
9. TM 9--Special Tools (Continued)

D. Test

E. Answers to test

II. Reference--Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. Modern Refrigeration and Air Conditioning. Homewood, Illinois: Goodheart-Willcox Co., 1975.

SPECIAL TOOLS
UNIT I

INFORMATION SHEET

I. Terms and definitions

   A. Charging--Replacing or adding refrigerant to an air conditioning system

   B. Evacuating--Using a vacuum pump to pull a vacuum on an air conditioning system for the purpose of removing air and moisture

   C. Conduit--Tubular enclosure for electrical conductors

   D. Thermal electric lead--Lead made up of two dissimilar metals which creates a small amount of voltage upon temperature change

   E. Hygrometer--Humidity sensing device

   F. High vacuum--Vacuum of 2000 to .1 microns and requires a two stage pump; also called a deep vacuum

   (NOTE: One inch of mercury vacuum is equal to 25,400 microns.)

   G. Manometer--Instrument consisting of a "U" shaped glass tube with either mercury of water in it for the measurement of pressure gases

   H. Hermetic--Sealed system

   I. Combustion--Burning of fuels

II. Specialized tools

   A. Refrigeration gauge set (Transparency 1)

   B. Leak detectors (Transparency 1)

      1. Soap solution

      2. Halide torch

      3. Electronic

C. Pullers (Transparency 2)
   1. Wheel
   2. Bearing
   3. Gear

D. Thermometers (Transparency 3)
   1. Flue and stack
   2. Thermal electric

E. Hygrometers (Transparency 3)
   1. Sling psychrometer
   2. Dial type
   3. Humidity recorder

F. Vacuum pumps (Transparency 4)
   1. Low vacuum
   2. High vacuum

G. Vacuum indicators (Transparency 4)
   1. Compound gauge
   2. Mercury manometer
   3. Thermocouple micron gauge

H. Capillary tube cleaners (Transparency 5)
   1. Manual
   2. Hydraulic

I. Charging cylinder (Transparency 5)

J. Service valves (Transparency 5)
   1. Hermetic service valve kit
   2. Access core type valves
   3. Process tube adapters
   4. Line piercing valves

K. Scales (Transparency 6)

L. Fin combs (Transparency 6)

M. Oil pump (Transparency 6)

N. Combustion testing kit (Transparency 6)

O. Air meters (Transparency 7)

  1. Aneometer

  2. Pitot tube

  3. Incline manometer

P. Sheet metal tools (Transparency 8)

  1. Hand notcher

  2. Hand beamer

  3. Riveting hammer

  4. Aviation snips

    a. Right-hand

    b. Left-hand

  5. Double cutting snips

  6. Hand crimper

  7. Combination pattern snips

Q. Refrigeration ratchet (Transparency 8)

III. Use of specialized tools

A. Refrigeration gauge set--For charging, evacuating, and checking pressures on refrigerant systems

B. Leak detectors--For locating refrigerant leaks

C. Pullers

  1. Wheel--For removing pulleys and bearings from motor shafts

  2. Bearing--For removing or installing bearings and bushings in motors

   3. Gear--For removing small pulleys or gears from motor shafts

D. Thermometers

   1. Flue and stack--For checking the temperatures created in gas flues and stacks

      (NOTE: The temperature range on these thermometers is generally 200°F to 1000°F.)

   2. Thermal electric--For measuring temperatures from 50°F to as high as +1000°F

      (NOTE: This temperature indicating meter is generally capable of checking more than one temperature through the use of multiple leads and by changing the function switch.)

E. Hygrometers

   1. Sling psychrometer--Wet-bulb and dry-bulb temperatures will be obtained by whirling the psychrometer for 15 to 20 seconds

      (NOTE: Dry-bulb temperature is the temperature of the air as indicated by an ordinary thermometer. The wet-bulb temperature is the temperature by evaporation.)

   2. Dial type--Contains human hair that reacts to humidity changes which gives a meter reading

   3. Humidity recorder--Records humidity changes on a time chart

F. Vacuum pumps

   1. Low vacuum--For evacuating a refrigeration system; used in conjunction with a gauge manifold

   2. High vacuum--For evacuating a refrigeration system; used in conjunction with a high vacuum gauge manifold and micron gauge

      (NOTE: These pumps are capable of pulling a vacuum below 50 microns and are used on large air-conditioning and heat pump systems.)

G. Vacuum indicators

  1. Compound gauge--Indicates vacuum accurately to 25 inches of mercury

  2. Mercury manometer--Indicates an accurate vacuum reading below 25 inches; used with a vacuum pump

  3. Thermocouple micron gauge--An extremely accurate vacuum indicator; used in conjunction with a high vacuum pump

H. Capillary tube cleaner

  1. Manual--Forces oil or R-11 through a capillary tube when the pressure handle is turned clockwise

  2. Hydraulic--Forces oil or R-11 through a capillary tube with the use of a hydraulic pump

     (NOTE: Remove capillary tubes from system before cleaning.)

I. Charging cylinder--For charging the proper amount of refrigerant into a system; used with a gauge manifold set

J. Service valves

  1. Hermetic service valve kit--Allows the connection of refrigeration gauges to some hermetic systems

     (NOTE: This valve kit is essential when servicing some brands of air conditioning systems.)

  2. Access core type valves--Allow the refrigerant system pressures to be checked when the gauge hose depresses the core

     (NOTE: These valves are commonly referred to as Schrader valves.)

  3. Process tube adapters--Provide a gauge connection by fitting onto the end of the charging stubs

(NOTE: These adapters must be removed after the stub has been pinched off and prior to soldering end of stub.)

4. Line piercing valves--Allow a gauge connection by tightening onto a charging stub and piercing it

   (NOTE: These valves are commonly referred to as line taps.)

K. Scales--For weighing the amount of refrigerant during the charging process

L. Fin combs--For straightening the heat transfer fins on condensers and evaporators

M. Oil pump--For putting oil into a a compressor without the danger of contamination

N. Combustion testing kit--For servicing gas or oil furnaces to detect CO_2 content, draft, stack temperature, and smoke

O. Air meters

1. Aneometer--Measures the speed of the air being supplied through a grille

   (NOTE: This measurement is expressed in feet per minute.)

2. Pitot tube--Determines air speed by obtaining air pressure through a grille

   (NOTE: This instrument is used in conjunction with a direct reading meter or an incline manometer.)

3. Incline manometer--Used with a pitot tube to determine air velocity pressure and static pressure

P. Combination pattern snips--For all general purpose cutting of sheet metal

(NOTE: The blades of the combination snips are designed to permit the metal to curve up out of the way when making circular cuts.)

Q. Hand notcher--For cutting notches in the edge of sheet metal

R. Hand seamer--For forming a seam on a piece of sheet metal, by hand

S. Riveting hammer--For forming the sheet metal

(NOTE: The edges are beveled to prevent marking of the metal.)

T. Aviation snips

  1. Right-hand--For cutting sheet metal in a right-handed direction

  2. Left-hand--For cutting sheet metal in a left-handed direction

  (NOTE: The right-hand and left-hand snips can be distinguished by the position of the upper blade. When the snips are held in a position to cut the metal, if the upper blade is on the operator's right, then they are right-hand snips. If, in this position, the upper blade is on the left, they are left-hand snips.)

U. Double cutting snips--For cutting sheet metal where both pieces of metal must lay flat

V. Hand crimper--For crimping the end of sheet metal pipe so that sections may be fitted together

W. Refrigeration ratchet--For front seating and back seating service valves and acetylene cylinder valves

IV. Care of specialized tools

A. Refrigeration gauge set

  1. Keep hoses plugged

  2. Check gauge calibration

  3. Oil manifold hand valve stems twice a year

  (NOTE: Two drops of oil on each shaft is sufficient.)

  4. Replace gauge lenses if cracked or broken

(NOTE: Do not allow oil from refrigeration system to enter manifold gauge because this will damage the gauge.)

B. Leak detectors

1. Clean orifice and hose of halide torch

2. Electronic leak detectors

   a. Do not drop

   b. Keep probe clean

   c. Do not use around a heavy concentration of refrigerant

C. Pullers

1. Keep tip pointed

2. Oil threaded shaft

3. Do not drop

D. Thermometers

1. Do not drop

2. Do not kink remote bulb capillaries

3. Use only in proper temperature range

4. Check batteries on thermal electric

E. Hygrometers

1. Do not drop

2. Use distilled water on wet-bulb wick

3. Keep in case when not in use

4. Change wick frequently

F. Vacuum pumps

1. Change oil often

(NOTE: Vacuum pump manufacturers recommend changing the oil after every evacuation.)

2. Keep clean

G. Vacuum indicators

1. Do not drop
2. Keep clean
3. Store in safe place when not in use

H. Capillary tube cleaner

1. Keep clean
2. Do not overpressurize gauge on hydraulic pump type

I. Charging cylinders

1. Keep clean
2. Do not drop or knock over
3. If refrigerant is left in cylinder, tag it as to type of refrigerant
4. Do not heat with a torch

J. Service valves

1. Do not overtighten hermetic service valves

   (NOTE: Overtightening will cause the valve adapters that are used with the hermetic service valve kit to break.)

2. Do not overtighten valve cores

   (NOTE: Overtightening will strip out the valve cores.)

3. Remove line piercing valves after system servicing is over

K. Scales

1. Do not try to weigh objects heavier than the limits of the scales
2. Do not try to weigh objects with the scale dial in the locked position

L. Fin combs--Do not drop

   (NOTE: Dropping will alter the preset spacing of the comb teeth.)

M. Oil pump

   1. Keep clean
   2. Put away when not in use
   3. Always replace cap to prevent oil contamination

N. Combustion testing kit

   1. Read instructions included in kit
   2. Store in a safe place when not in use

O. Air meters

   1. Do not drop
   2. Store in a safe place when not in use

P. Combination pattern snips

   1. Do not throw or drop
   2. Keep sharp
   3. Oil swivel point

Q. Hand notcher

   1. Use only on proper gauge metal
   2. Oil
   3. Do not throw or drop

R. Hand seamer

   1. Keep clean and oiled
   2. Do not throw or drop

S. Riveting hammer

   1. Do not throw or drop
   2. Keep handle tight

T. Aviation snips
   1. Do not throw or drop
   2. Keep sharp
   3. Keep oiled and clean

U. Double cutting snips
   1. Do not throw or drop
   2. Keep sharp
   3. Keep oiled and clean

V. Hand crimper
   1. Do not throw or drop
   2. Keep oiled and clean

W. Refrigeration ratchet
   1. Do not apply excessive force on ratchet mechanism
   2. Oil
   3. Do not use as a hammer

V. Refrigeration gauge set components (Transparency 9)

A. Gauge manifold
   1. Body
   2. Hand valves
   3. Hose ports
   4. Gauge ports

B. Compound gauge
   1. Pressure 0 - 200 p.s.i.g.
   2. Vacuum 0 - 30 inches of mercury
   3. Recalibration screw
   4. Lens

- C. Pressure gauge
    - 1. Pressure 0 - 500 p.s.i.g.
    - 2. Recalibration screw
    - 3. Lens
- D. Refrigerant hose
    - 1. Neoprene
    - 2. 1/4" female flare ends
    - 3. Valve core depressors
- E. Hose holder
    - 1. Fits on manifold
    - 2. 1/4" male flare fittings
    - 3. Hook

VI. Use of refrigeration gauge set components

- A. Gauge manifold
    - 1. Charging
    - 2. Evacuating
    - 3. Checking pressures
- B. Compound gauge
    - 1. Charging vapor
    - 2. Evacuating
    - 3. Pressurizing
    - 4. Checking low side pressures
- C. Pressure gauge
    - 1. Charging into high side
    - 2. Evacuating through both sides
    - 3. Pressurizing

    4. Checking high side pressures

D. Refrigerant hoses

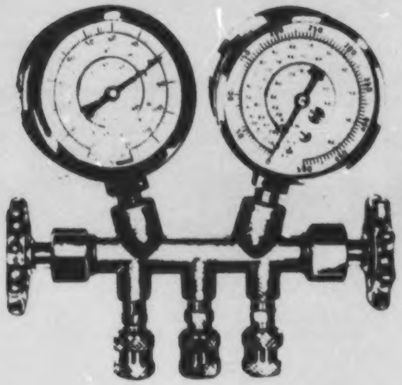
    1. Charging
    2. Evacuating
    3. Pressurizing
    4. Checking pressures

E. Hose holder

    1. Keeping hoses clean
    2. Holding hoses when not in use

Special Tools

Refrigeration Gauge Set

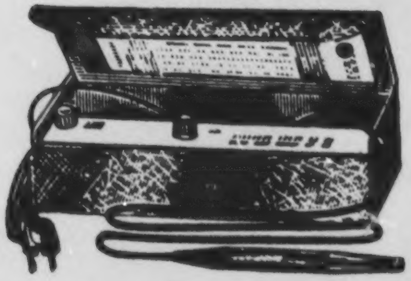


Leak Detectors

Soap Solution

Halide Torch

Electronic



TM-1

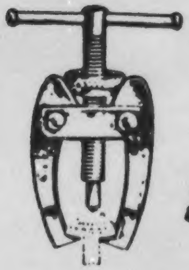
8-19-J

Special Tools

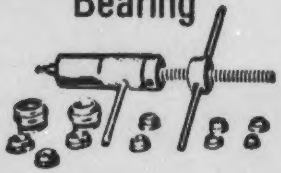
(Continued)

Pullers

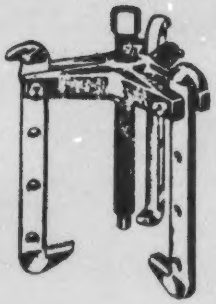
Gear



Bearing



Wheel

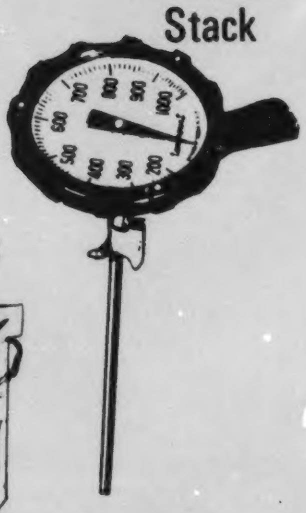


Special Tools

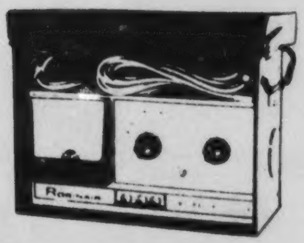
Thermometers

(Continued)

Flue and Stack



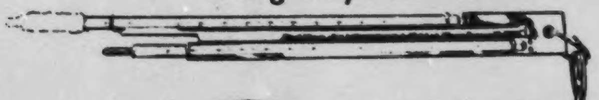
Thermal Electric



Hygrometers

Humidity Recorder

Sling Psychrometer



Dial Type

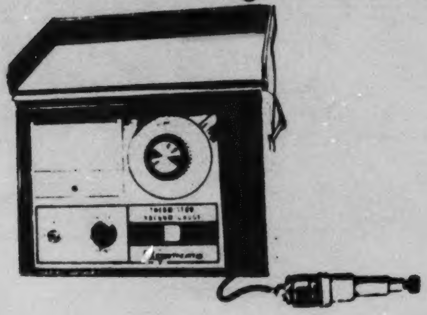
TM 3

Special Tools

(Continued)

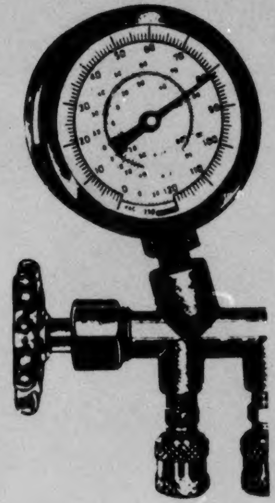
Vacuum Indicators

Thermocouple Micron Gauge



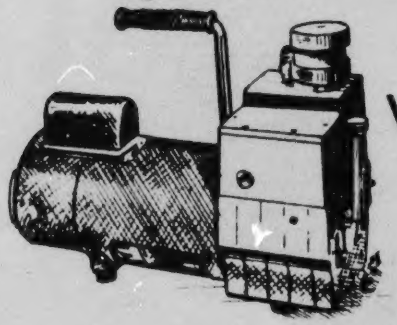
Mercury Manometer

Compound Gauge

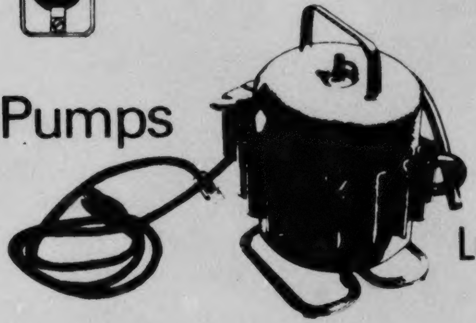


Vacuum Pumps

High Vacuum



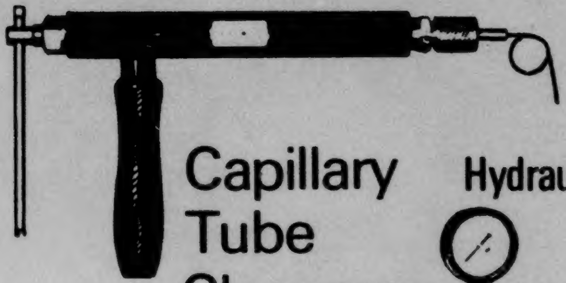
Low Vacuum



Special Tools

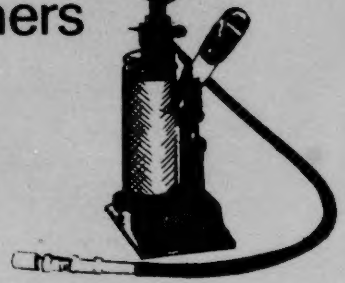
(Continued)

Manual

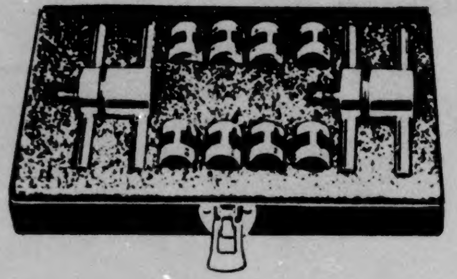


Capillary Tube Cleaners

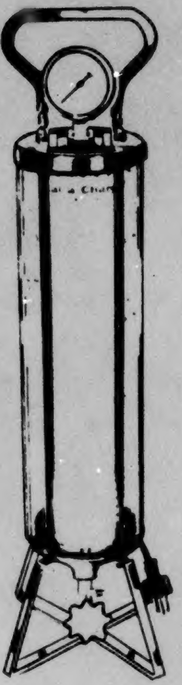
Hydraulic



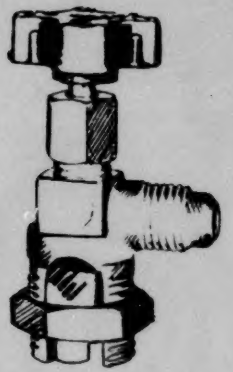
Process Tube Adapters



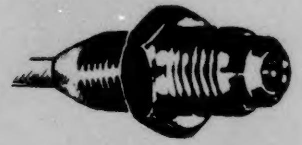
Charging Cylinder



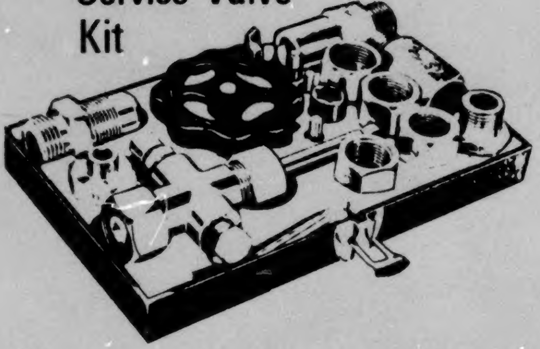
Line Piercing Valve



Access Core Type Valve



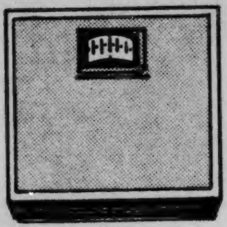
Hermetic Service Valve Kit



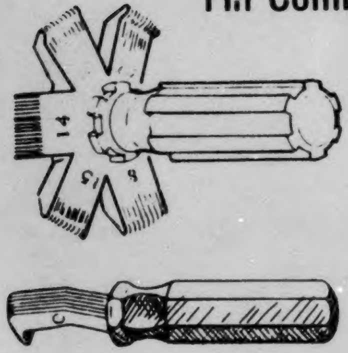
Special Tools

(Continued)

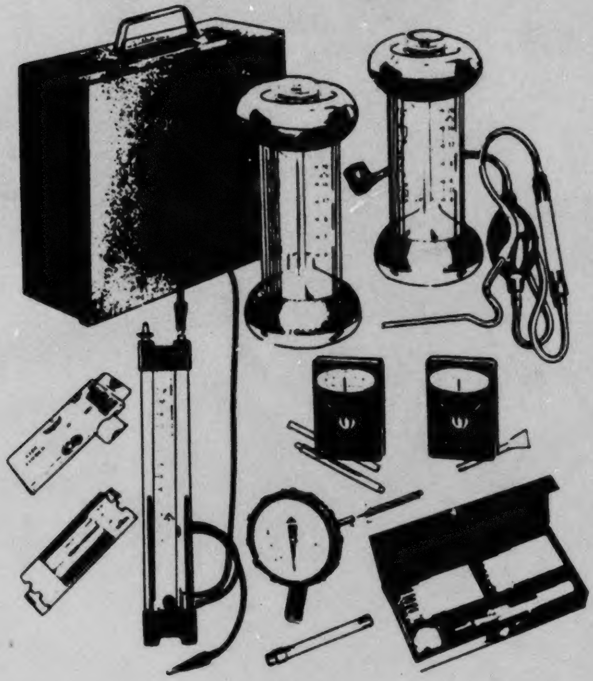
Oil Pump



Scales



Fin Combs

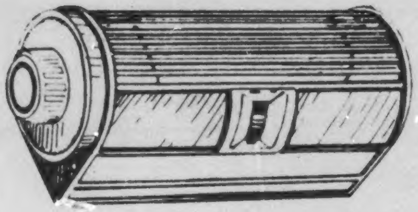


Combustion Testing Kit

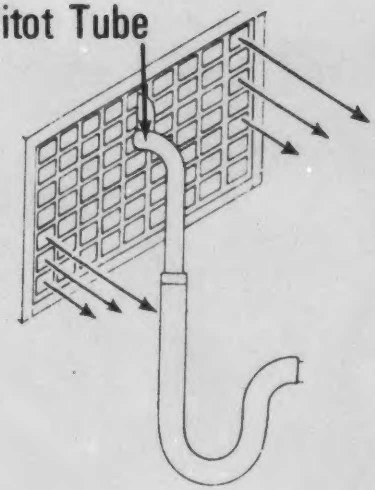
Special Tools

(Continued)

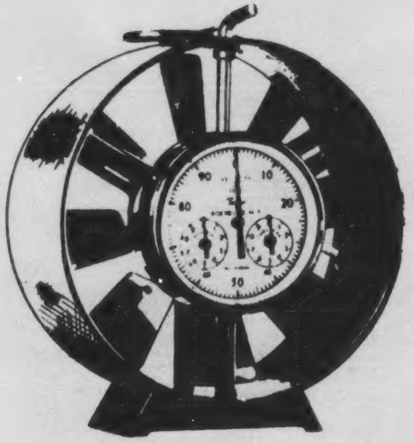
Aneometer



Pitot Tube

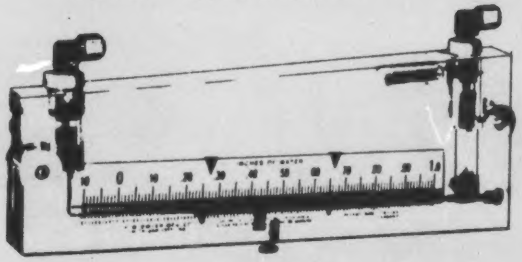


Aneometer



Air Meters

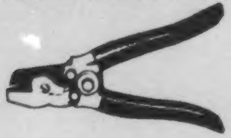
Incline Manometer



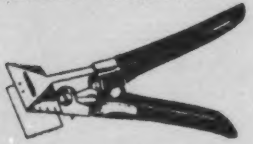
Special Tools

(Continued)

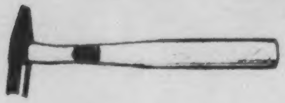
Hand Notcher



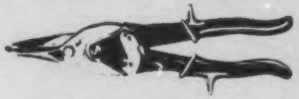
Hand Seamer



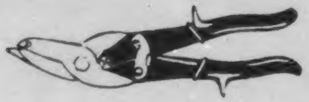
Riveting Hammer



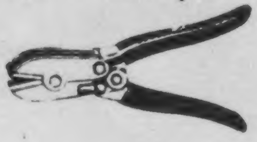
Aviation Snips



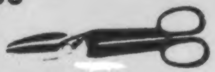
Double Cutting Snips



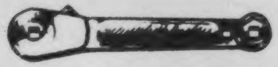
Hand Crimper



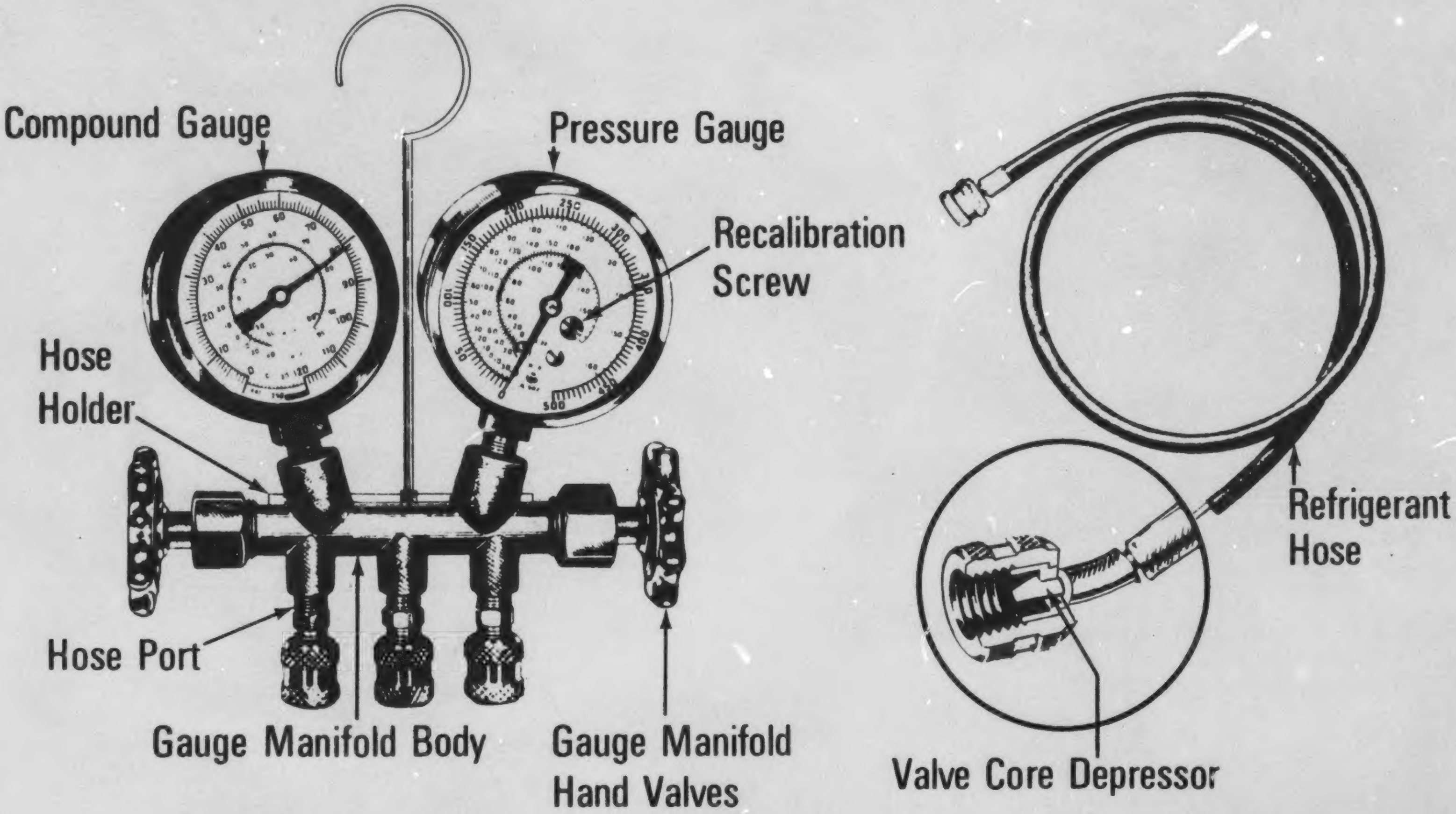
Combination Pattern Snips



Refrigeration Ratchet



Refrigeration Gauge Set Components



TM - 9

S-35-J

SPECIAL TOOLS
UNIT I

NAME______________________________

TEST

1. Match the terms on the right to the correct definitions.

_____a. Humidity sensing device

_____b. Instrument consisting of a "U" shaped glass tube with either mercury or water in it for the measurement of pressure gases

_____c. Tubular enclosure for electrical conductors

_____d. Replacing or adding refrigerant to an air conditioning system

_____e. Vacuum of 2000 to .1 microns and requires a two stage pump; also called a deep vacuum

_____f. Using a vacuum pump to pull a vacuum on an air conditioning system for the purpose of removing air and moisture

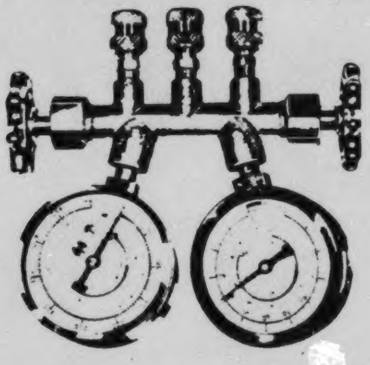
_____g. Sealed system

_____h. Burning of fuels

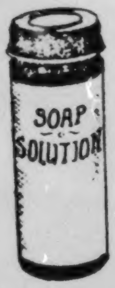
_____i. Lead made up of two dissimilar metals which creates a small amount of voltage upon temperature change

1. Hygrometer
2. High vacuum
3. Conduit
4. Evacuating
5. Charging
6. Thermal electric lead
7. Manometer
8. Hermetic
9. Combustion

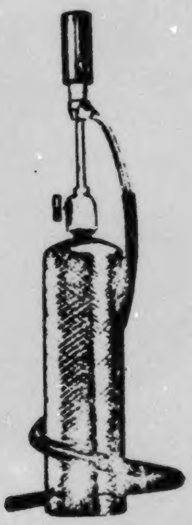
2. Identify specialized tools.



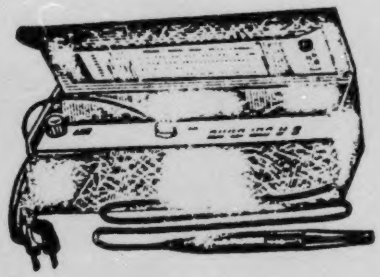
a. ______________________



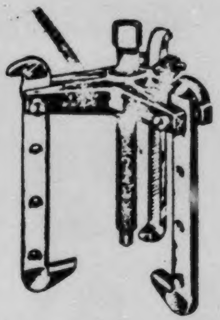
b. ______________________



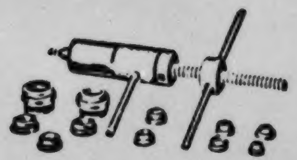
c. ______________________



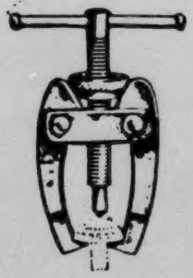
d. ______________________



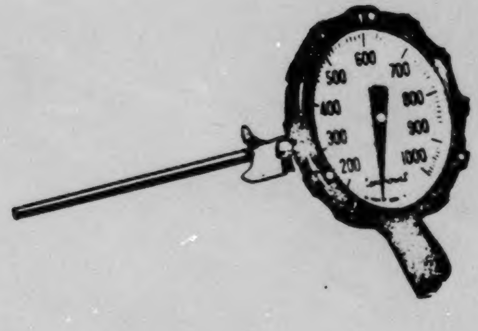
e. ______________________

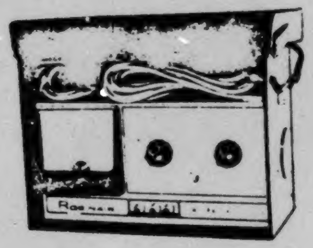


f. ____________________



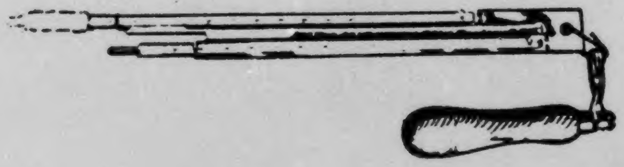
g. ____________________

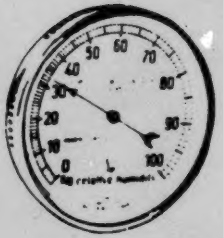

200
300
400
500
600
700
800
900
1000



i. ____________________

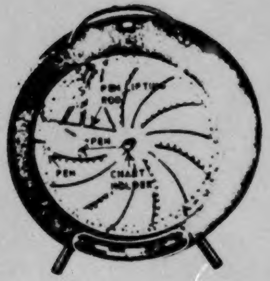
h. ____________________

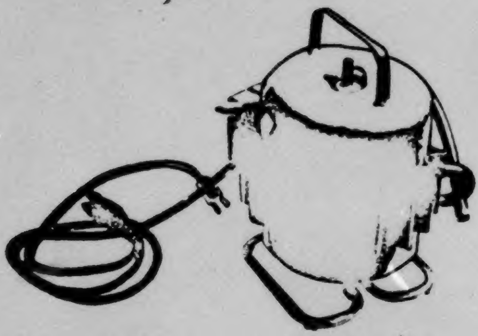



0
10
20
30
40
50
60
70
80
90
100
% relative humidity

j. ____________________

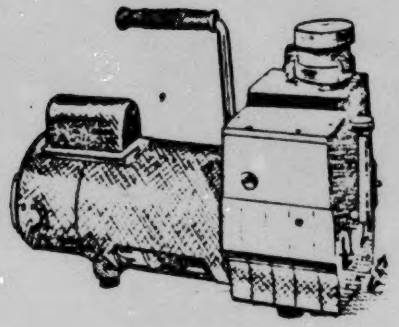
k. ____________________

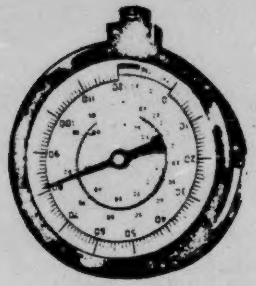




l. ______________________

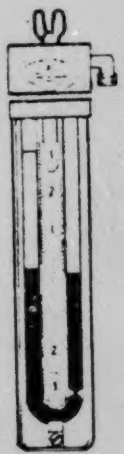
m. ______________________

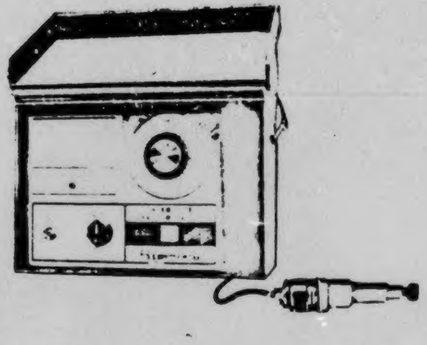




n. ______________________

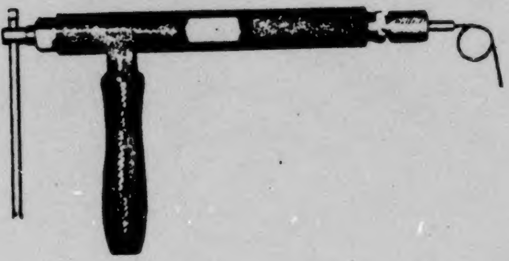
o. ______________________

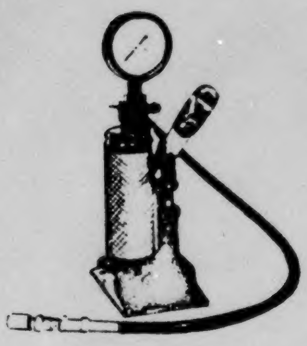




p. ______________________

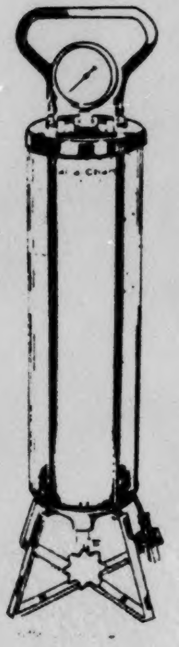
q. ______________________

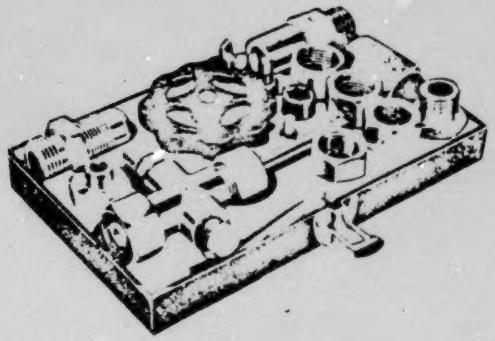




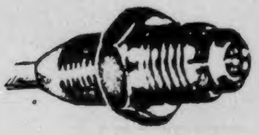
r. ______________________

s. ______________________



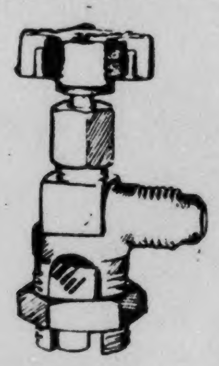


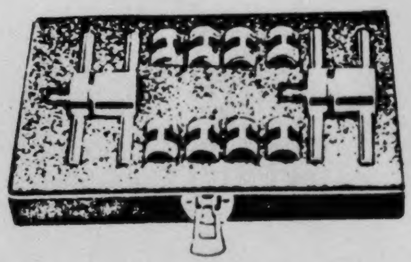
u. ______________________



t. ______________________

v. ______________________

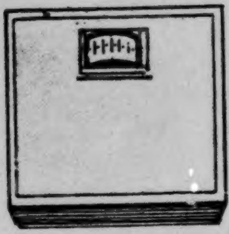




w. ______________________

x. ______________________

1074



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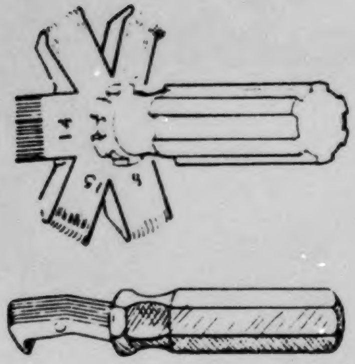
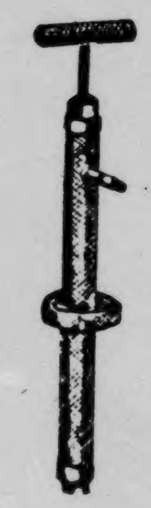


z. ______________________



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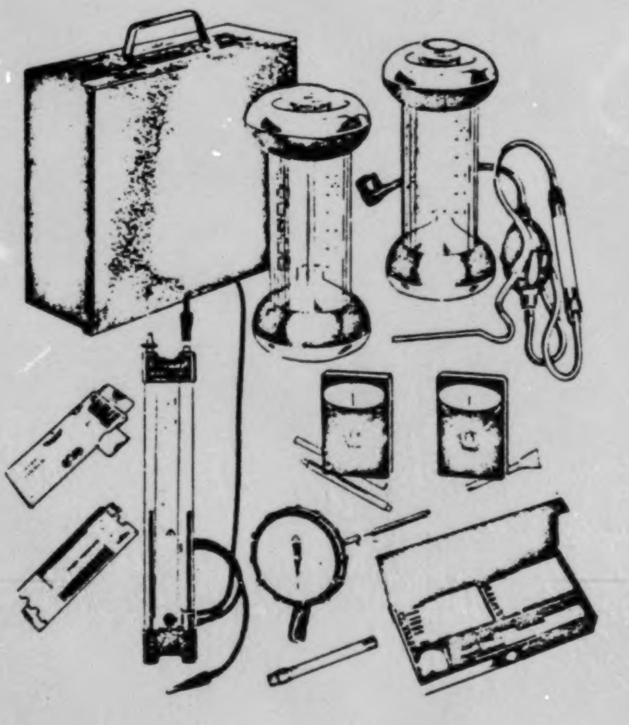

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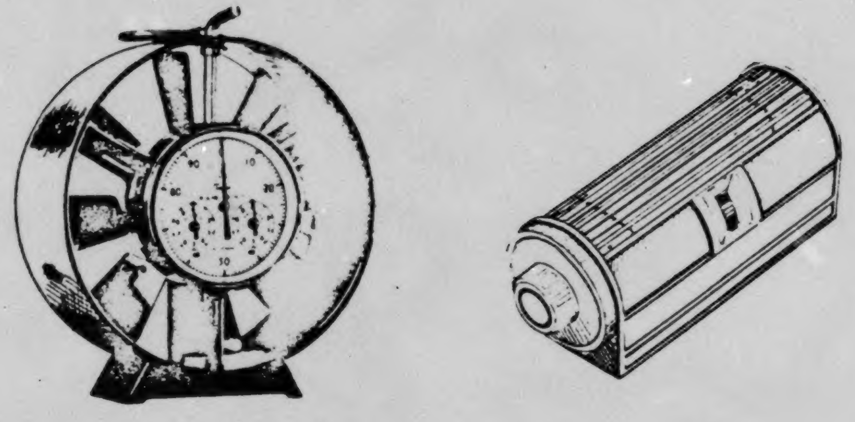
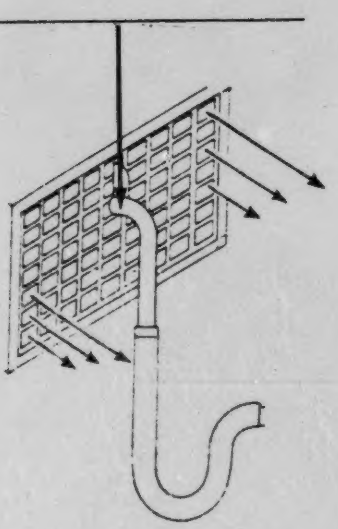
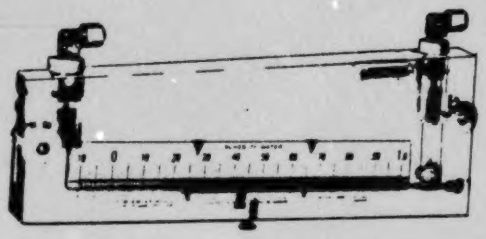


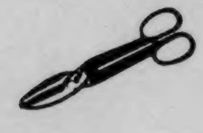
cc. ____________________

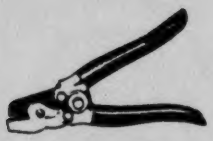
dd. ____________________





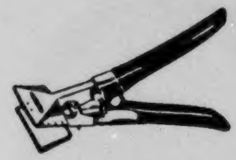
ee. ____________________

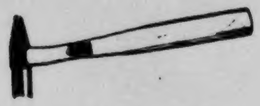




ff. ____________________

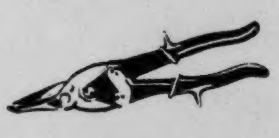
gg. ____________________

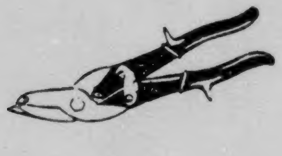




hh. ____________________

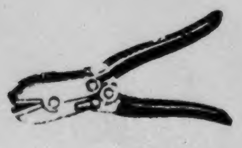
ii. ____________________

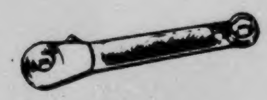




jj. ____________________

kk. ____________________





ll. ____________________

mm. ____________________

3. Describe the use of the specialized tools.

   a. Thermometers

      1. Flue and stack--______________________________

         ____

      2. Thermal electric--______________________________

         ____

   b. Leak detectors--______________________________

   c. Vacuum pumps

      1. High vacuum--______________________________

         ____

      2. Low vacuum--______________________________

         ____

   d. Capillary tube cleaners

      1. Manual--______________________________

         ____

      2. Hydraulic--______________________________

         ____

   e. Oil pump--______________________________

      ____

   f. Service valves

      1. Access core type valves--______________________________

         ____

      2. Process tube adapters--______________________________

         ____

      3. Hermetic service valve kit--______________________________

         ____

4. Line piercing valves--________________________

g. Pullers

1. Gear--________________________

2. Bearing--________________________

3. Wheel--________________________

h. Scales--________________________

i. Combination pattern snips--________________________

j. Refrigeration ratchet--________________________

k. Refrigeration gauge set--________________________

m. Hand notcher--________________________

n. Vacuum indicators

1. Mercury manometer--________________________

2. Compound gauge--________________________

3. Thermocouple micron gauge--________________________

o. Hand crimper--

p. Aviation snips

1. Right-hand--

2. Left-hand--

q. Hygrometers

1. Sling psychrometer--

2. Dial type--

3. Humidity recorder--

r. Combustion testing kit--

s. Charging cylinder--

t. Fin combs--

u. Double cutting snips--

v. Air meters

1. Incline manometer--

2. Pitot tube--______________________________

____

3. Aneometer--______________________________

____

w. Riveting hammer--______________________________

____

x. Hand seamer--______________________________

____

4. Describe the care of the specialized tools.

a. Thermometers

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________

b. Leak detectors

1. ______________________________
2. ______________________________
   a. ______________________________
   b. ______________________________
   c. ______________________________

c. Vacuum pumps

1. ______________________________
2. ______________________________

d. Capillary tube cleaners

1. ______________________________
2. ______________________________

e. Oil pump
    1. ______________________________
    2. ______________________________
    3. ______________________________

f. Service valves
    1. ______________________________
    2. ______________________________
    3. ______________________________

g. Pullers
    1. ______________________________
    2. ______________________________
    3. ______________________________

h. Scales
    1. ______________________________
    2. ______________________________
    ____

i. Combination pattern snips
    1. ______________________________
    2. ______________________________
    3. ______________________________

j. Refrigeration ratchet
    1. ______________________________
    2. ______________________________
    3. ______________________________

k. Refrigeration gauge set
    1. ______________________________

    2. ______________________________
    3. ______________________________
    4. ______________________________

l. Hand notcher

    1. ______________________________
    2. ______________________________
    3. ______________________________

m. Vacuum indicators

    1. ______________________________
    2. ______________________________
    3. ______________________________

n. Hand crimper

    1. ______________________________
    2. ______________________________

o. Aviation snips

    1. ______________________________
    2. ______________________________
    3. ______________________________

p. Hygrometers

    1. ______________________________
    2. ______________________________
    3. ______________________________
    4. ______________________________

q. Combustion testing kit

    1. ______________________________
    2. ______________________________

r. Charging cylinders

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

s. Fin combs ______________________________

t. Double cutting snips

1. ______________________________

2. ______________________________

3. ______________________________

u. Air meters

1. ______________________________

2. ______________________________

v. Riveting hammer

1. ______________________________

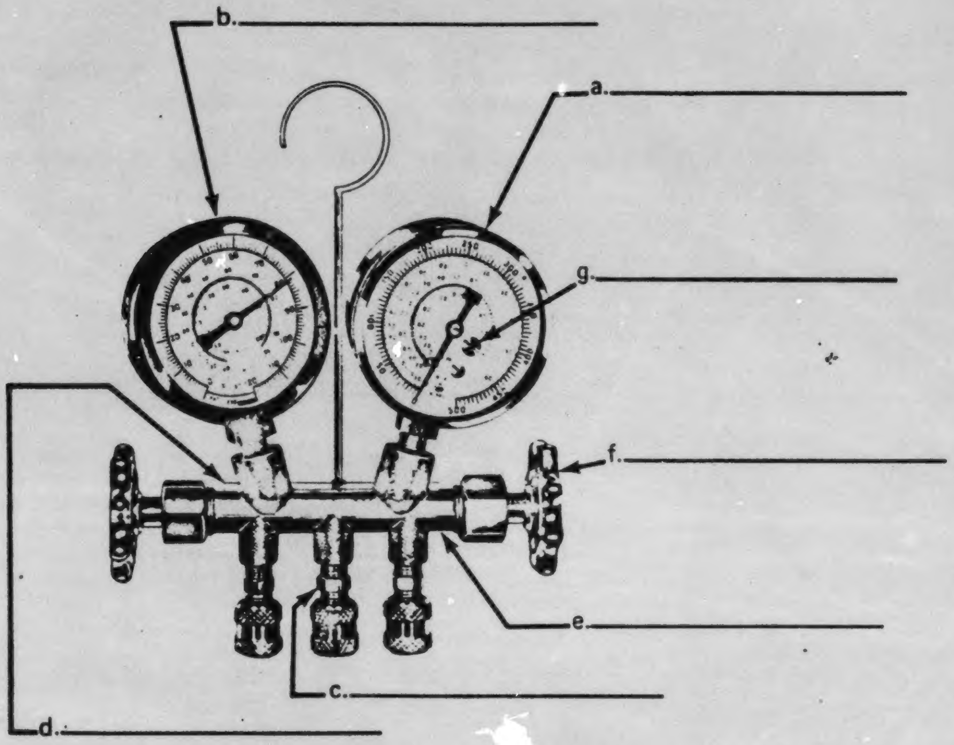
2. ______________________________

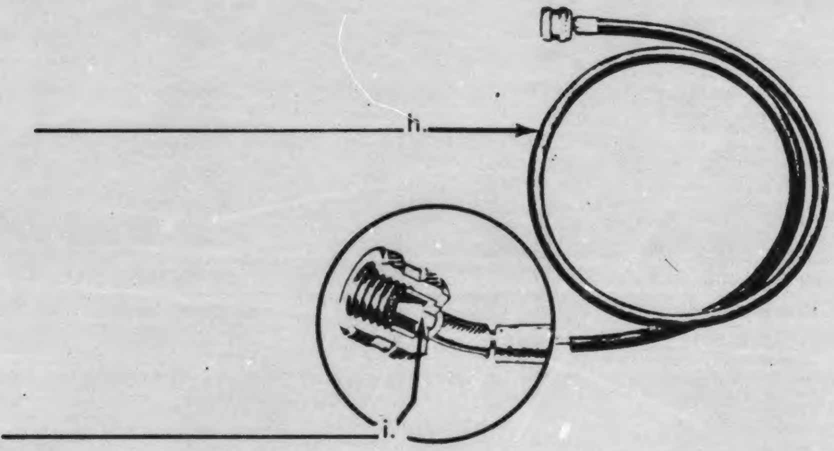
w. Hand seamer

1. ______________________________

2. ______________________________

5. Identify the components of the refrigeration gauge set.





6. List when each refrigeration gauge set component is used.

a. Gauge manifold

1. ______________________________

2. ______________________________

3. ______________________________

b. Compound gauge

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

c. Pressure gauge

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

d. Refrigerant hoses

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

e. Hose holder

1. ______________________________

2. ______________________________

SPECIAL TOOLS
UNIT I

ANSWERS TO TEST

1. a. 1
b. 7
c. 3
d. 5
e. 2
f. 4
g. 8
h. 9
i. 6

2. a. Refrigeration gauge set
b. Soap solution leak detector
c. Halide torch leak detector
d. Electronic leak detector
e. Wheel puller
f. Bearing puller
g. Gear puller
h. Flue and stack thermometer
i. Thermal electric thermometer
j. Sling psychrometer
k. Dial type hygrometer
l. Humidity recorder
m. Low vacuum pump
n. High vacuum pump
o. Compound gauge
p. Mercury manometer
q. Thermocouple micron gauge

r. Manual capillary tube cleaner

s. Hydraulic capillary tube cleaner

t. Charging cylinder

u. Hermetic service valve kit

v. Access core type valves

w. Process tube adapters

x. Line piercing valves

y. Scales

z. Fin comb

aa. Oil pump

bb. Combustion testing kit

cc. Aneometer

dd. Pitot tube

ee. Incline manometer

ff. Combination pattern snips

gg. Hand notcher

hh. Hand seamer

ii. Riveting hammer

jj. Aviation snips

kk. Double cutting snips

ll. Hand crimper

mm. Refrigeration ratchet

3. Description should include:

   a. Thermometers

      1. Flue and stack--For checking the temperatures created in gas flues and stacks

2. Thermal electric--For measuring temperatures from -50° to as high as +1000°F.

3. Remote bulb--For checking temperatures in one area and reading the temperature on a dial in another area

b. Leak detectors--For locating refrigerant leaks

c. Vacuum pumps

   1. High vacuum--For evacuating a refrigeration system; used in conjunction with a high vacuum gauge manifold and micron gauge

   2. Low vacuum--For evacuating a refrigeration system; used in conjunction with a gauge manifold

d. Capillary tube cleaners

   1. Manual--Forces oil or R-11 through a capillary tube when the pressure handle is turned clockwise

   2. Hydraulic--Forces oil or R-11 through a capillary tube with the use of a hydraulic pump

e. Oil pump--For putting oil into a compressor without the danger of contamination

f. Service valves

   1. Access core type valves--Allow the refrigerant system pressures to be checked when the gauge hose depresses the core

   2. Process tube adapters--Provides a gauge connection by fitting onto the end of charging stubs

   3. Hermetic service valve kit--Allows the connection of refrigeration gauges to some hermetic systems

   4. Line piercing valves--Allow a gauge connection by tightening onto a charging stub and piercing it

g. Pullers

   1. Gear--For removing small pulleys or gears from motor shafts

2. Bearing--For removing or installing bearings and bushings in motors

3. Wheel--For removing pulleys and bearings from motor shafts

h. Scales--For weighing the amount of refrigerant during the charging process

i. Combination pattern snips--For all general purpose cutting of sheet metal

j. Refrigeration ratchet--For front seating and back seating service valves and acetylene cylinder valves

k. Refrigeration gauge set--For charging, evacuating, and checking pressures on refrigeration systems

l. Hand notcher--For cutting notches in the edge of sheet metal

m. Vacuum indicators

1. Mercury manometer--Indicates an accurate vacuum reading below 25 inches; used with a vacuum pump

2. Compound gauge--Indicates vacuum accurately to 25 inches of mercury

3. Thermocouple micron gauge--An extremely accurate vacuum indicator; used in conjunction with a high vacuum pump

n. Hand crimper--For crimping the end of sheet metal pipe so that sections may be fitted together

o. Aviation snips

1. Right-hand--For cutting sheet metal in a right-handed direction

2. Left-hand--For cutting sheet metal in a left-handed direction

p. Hygrometers

1. Sling psychrometer--Wet-bulb and dry-bulb temperature will be obtained by whirling the psychrometer for 15 to 20 seconds

2. Dial type--Contains human hair that reacts to humidity changes which gives a meter reading

3. Humidity recorder--Records humidity changes on a time chart

q. Combustion testing kit--For servicing gas or oil furnaces to detect CO_2 content, draft, stack temperature, and smoke

r. Charging cylinder--For charging the proper amount of refrigerant into a system; used with a gauge manifold set

s. Fin combs--For straightening the heat transfer fins on condensers and evaporators

t. Double cutting snips--For cutting sheet metal where both pieces of metal must lay flat

u. Air meters

1. Incline manometer--Used with a pitot tube to determine air velocity pressure and static pressure

2. Pitot tube--Determines air speec by obtaining air pressure through a grille

3. Aneometer--Measure the speed of the air being supplied through a grille

v. Riveting hammer--For forming the sheet metal

w. Hand seamer--For forming a seam on a piece of sheet metal, by hand

4. Description should include:

a. Thermometers

1. Do not drip

2. Do not kink remote bulb capillaries

3. Use only in proper temperature range

4. Keep pocket thermometers in case when not in use

5. Check batteries on thermal electric

b. Leak detectors

1. Clean orifice and hose of halide torch

2. Electronic leak detectors

a. Do not drop

b. Keep probe clean

c. Do not use around a heavy concentration of refrigerant

c. Vacuum pumps

1. Change oil often

2. Keep clean

d. Capillary tube cleaners

1. Keep clean

2. Do not overpressurize gauge on hydraulic pump type

e. Oil pump

1. Keep clean

2. Put away when not in use

3. Always replace cap to prevent oil contamination

f. Service valves

1. Do not overtighten hermetic service valves

2. Do not overtighten valve cores

3. Remove line piercing valves after system servicing is over

g. Pullers

1. Keep tip pointed

2. Oil threaded shaft

3. Do not drop

h. Scales

   1. Do not try to weigh objects heavier than the limits of the scales

   2. Do not try to weigh objects with the scale dial in the locked position

i. Combination pattern snips

   1. Do not throw or drop

   2. Keep sharp

   3. Oil swivel point

j. Refrigeration ratchet

   1. Do not apply excessive force on ratchet mechanism

   2. Oil

   3. Do not use as a hammer

k. Refrigeration gauge set

   1. Keep hoses plugged

   2. Check gauge calibration

   3. Oil manifold hand valve stems twice a year

   4. Replace gauge lenses if cracked or broken

l. Hand notcher

   1. Use only on proper gauge metal

   2. Oil

   3. Do not throw or drop

m. Recording thermometers

   1. Do not drop

   2. Do not wind clock too tight on manual wind

   3. Place recorder where it will not be knocked off

n. Vacuum indicators
   1. Do not drop
   2. Keep clean
   3. Store in safe place when not in use

o. Hand crimper
   1. Do not throw or drop
   2. Keep oiled and clean

p. Aviation snips
   1. Do not throw or drop
   2. Keep sharp
   3. Keep oiled and clean

q. Hygrometers
   1. Do not drop
   2. Use distilled water on wet-bulb wick
   3. Keep in case when not in use
   4. Change wick frequently

r. Combustion testing kit
   1. Read instructions included in kit
   2. Store in a safe place when not in use

s. Charging cylinders
   1. Keep clean
   2. Do not drop or knock over
   3. If refrigerant is left in cylinder, tag it as to type of refrigerant
   4. Do not heat with a torch

t. Fin combs--Do not drop

- u. Double cutting snips
  - 1. Do not throw or drop
  - 2. Keep sharp
  - 3. Keep oiled and clean
- v. Air meters
  - 1. Do not drop
  - 2. Store in a safe place when not in use
- w. Riveting hammer
  - 1. Do not throw or drop
  - 2. Keep handle tight
- x. Hand seamer
  - 1. Keep clean and oiled
  - 2. Do not throw or drop

5. a. Pressure gauge
   - b. Compound gauge
   - c. Hose port
   - d. Hose holder
   - e. Gauge manifold body
   - f. Gauge manifold hand valves
   - g. Recalibration screw
   - h. Refrigerant hose
   - i. Valve core depressor
6. a. Gauge manifold
   - 1. Charging
   - 2. Evacuating
   - 3. Checking pressures

b. Compound gauge
    1. Charging vapor
    2. Evacuating
    3. Pressurizing
    4. Checking low side pressures

c. Pressure gauge
    1. Charging into high side
    2. Evacuating through both sides
    3. Pressurizing
    4. Checking high side pressures

d. Refrigerant hoses
    1. Charging
    2. Evacuating
    3. Pressurizing
    4. Checking pressures

e. Hose holder
    1. Keeping hoses clean
    2. Holding hoses when not in use

7. Performance skill evaluated to the satisfaction of the instructor

SOLAR ASSISTED HEAT PUMP SYSTEMS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms and definitions associated with solar assisted heat pumps and describe types of heat pumps in common use. The student should also be able to identify system components and select correct circulator pumps. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with solar assisted heat pumps to their correct definitions.
2. List three forms of energy a solar assisted heat pump is designed to utilize.
3. List four types of energy to be considered in managing energy resources.
4. List four areas of consideration in calculating solar requirements.
5. Match three terms and definitions related to calculating a solar system output.
6. State the recommended capacity for storing energy for a solar assisted heat pump and list three design considerations.
7. Select three solar system components that are generally available from solar suppliers only.
8. Match terms related to heating phases of a solar assisted heat pump to their correct definitions.
9. List two characteristics of a solar assisted heat pump in summer operation for a heat pump system and a solar subsystem.
10. Discuss a domestic solar hotwater loop preheat piping circuit.

11. Match three functions of the collector loop with their correct components.

12. Match the components in the storage/terminal loop of a solar assisted heat pump system to their correct functions.

13. Match the components in a heat pump loop of a solar assisted heat pump system to their correct functions.

14. List an accepted method of calculating heating requirements with a heat gain/heat loss study.

15. Name four types of individuals qualified to design a solar assisted heat pump system.

16. List the method of rating collectors in net monthly output.

17. List four kinds of information provided by the monthly output data sheet on collectors.

18. State the priority consideration in the physical orientation of flat plate collectors.

19. Match statements related to collector tilt and orientation of flat plate collectors to their correct terms.

20. State two precautions related to the installation of flat plate collectors.

21. List three methods of circuiting collectors.

22. List two statements related to sizing of copper pipe in a solar system.

23. List two statements related to sizing of the collector loop pump and piping.

24. State the purpose of the expansion tank in a closed loop system.

25. Select components common to collector loops.

26. State the purpose of antifreeze in the heat transfer fluid and list the percentage of water and glycol solution used to provide a minus 32°F freeze protection.

27. State the instructions related to filling the collector loop with transfer fluid.

28. Describe two functions of the collector loop heat exchanger.

29. Select components in the storage/terminal loop.

30. Select the recommended size for a 30 ft. run of copper pipe for the terminal and storage loop.

31. Select components in a domestic hotwater loop.

32. Select components in the system control package.

33. List the number of functions simulated by the system operation analysis sheet.

34. Identify six low voltage loads illustrated in a solar diagram.

35. Identify three low voltage loads in a solar wiring diagram and six high voltage loads in a heat pump circuit of a solar assisted heat pump.

36. Demonstrate the ability to:

    a. Isolate solar heat circuits only in a wiring diagram

    b. Isolate heat pump circuits only in a wiring diagram

    c. Isolate relays, contacts, and motors for heat pump operation with solar sub-system support

    d. Isolate heat pump, first and second stage resistance heater circuits only, in a wiring diagram

    e. Install a collector loop for a solar assisted heat pump

    f. Install a split-heat pump system

    g. Install a storage/terminal loop

    h. Install a domestic water heater loop

SOLAR ASSISTED HEAT PUMP SYSTEMS
UNIT II

SUGGESTED ACTIVITIES

I. Instructor

   A. Provide student with objective sheet

   B. Provide student with information, assignment and job sheets

   C. Make transparencies

   D. Discuss unit and specific objectives

   E. Discuss information and assignment sheets

   F. Demonstrate and discuss the procedures outlined in the job sheets

   G. Review and discuss transparencies

   H. Review and discuss films on solar hydronic and heat pump systems

   I. Invite local solar heating dealer/contractors to speak to the class on solar assisted heat pumps

   J. Review and discuss solar assisted heat pump materials and/or manuals

   K. Give test

II. Student

   A. Read objective sheet

   B. Study information sheets

   C. Complete assignment and job sheets

   D. Take test

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

C. Transparency masters

1. TM 1--Solar Assisted Heat Pump Components
2. TM 2--Sequence of Heating Modes of the Solar Assisted Heat Pump
3. TM 3--Domestic Hotwater Preheat Loop
4. TM 4--Collector Loop
5. TM 5--Storage/Terminal Loop
6. TM 6--Heat Pump Loop
7. TM 7--Monthly Output, Collector Panel - MBTU
8. TM 8--Sun's Path
9. TM 9--Collector Tilt
10. TM 10--Collector Orientation
11. TM 11--Flat Plate Collector Installation
12. TM 12--Collector Arrays
13. TM 13--Equivalent Feet of Tubing for Fittings
14. TM 14--Collector Loop Pump and Pipe Sizes
15. TM 15--Expansion Tanks
16. TM 16--Sizing the Expansion Tank
17. TM 17--Collector Loop Components and Fittings
18. TM 18--Ethylene Glycol Mixture
19. TM 19--Solar Storage/Terminal Loop Components
20. TM 20--BTU Output of Sample Heat Pumps
21. TM 21--Output of Sample Hydronic Coils, MBTU
22. TM 22--Piping and Pumps for Storage/ Terminal Loops

23. TM 23--Heat Exchanger
24. TM 24--System Control Package
25. TM 25--System Control Package (Continued)
26. TM 26--System Operation Analysis
27. TM 27--Wiring Diagrams - Solar System
28. TM 28--Wiring Diagram - Solar Assisted Heat Pump

D. Assignment sheets
  1. Assignment Sheet #1--Isolate Solar Heat Circuits Only in a Wiring Diagram
  2. Assignment Sheet #2--Isolate Heat Pump Circuits Only in a Wiring Diagram
  3. Assignment Sheet #3--Isolate Relays, Contacts and Motors for Heat Pump Operation with Solar Subsystem Support
  4. Assignment Sheet #4--Isolate Heat Pump, First and Second Stage Resistance Heater Circuits Only, in a Wiring Diagram

E. Answers to assignment sheets

F. Job sheets
  1. Job Sheet #1--Install a Collector Loop for a Solar Assisted Heat Pump
  2. Job Sheet #2--Install a Split-Heat Pump System
  3. Job Sheet #3--Install a Storage/Terminal Loop
  4. Job Sheet #4--Install a Domestic Water Heater Preheat Loop

G. Test

H. Answers to test

II. References:

A. Solar Heating and Cooling of Residential Buildings - Sizing, Installation and Operation of Systems, 1977, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
Stock No. 003-011-00085-2

B. Fedders Solarflex™, Solar Assisted Heat Pump Manual, 1978, Fedders Corporation, Edison, New Jersey 08817

C. Richard H. Montgomery with Jim Budnick, The Solar Decision Book, Dow Corning Corporation, Midland, Michigan 48640, 1978, Library of Congress, Number 78-66403

SOLAR ASSISTED HEAT PUMP SYSTEMS
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. Auxiliary system--A supplementary heating unit to provide heat to a space when the solar system cannot meet the demand

(NOTE: Another term for auxiliary system is a backup system.)

B. Caulking--Making an airtight seal by filling in cracks around windows and/or doors

C. Collection--The act of trapping solar radiation and converting it to heat

D. Design temperature--A designated temperature used in estimating a building's heating and/or cooling requirements

E. Double-glazed--Collector that is covered with two layers of glass or other transparent material

F. Flow rate--The amount of heat transfer fluid that passes through the collector or storage loop in a selected time frame

(NOTE: The selected time frame is usually one minute.)

G. Galvanic corrosion--The condition caused by contact of two different metals not properly isolated

H. Glazing--A covering of transparent material used for admitting light

(NOTE: A transparent material would be glass or plastic.)

I. Header--The pipe that runs across the edge of an array or solar collectors distributing the heat transfer fluid to or from risers in the individual collectors

J. Heat distribution--The act of conveying solar heat from collectors to areas to be heated

K. Heat gain--An increase in the amount of heat contained in a space

L. Heat loss--A decrease in the amount of heat contained in a space

M. Heat storage--Medium that absorbs collected solar heat and holds it until needed

N. Infiltration--The uncontrolled movement of outdoor air into the conditioned space

O. Resistance heating--A standard method of converting electricity into heat

P. Space heating--Heating of the air inside a building

Q. Specific heat--The number of Btu's required to raise the temperature of one pound of water 1°F

R. Stagnation temperature--High temperature reached inside a collector when the heat transfer fluid is not circulating on sunny days

S. Ultraviolet radiation--Radiation that has a deteriorating effect on unprotected pipe insulation and other exposed materials

T. Vapor barrier--Plastic sheeting that is used to prevent condensation in walls and other locations of insulation

II. Introduction to the solar assisted heat pump

A. Designed to utilize

1. Radiant solar energy--Used to supply the heating needs during sunny days

2. Reverse cycle heat pump outlet--Used to supply heating needs when solar collected heat is unable to meet demands

3. Electric resistance heat

a. Used to support the heat pump output when the heat pump and solar collected heat cannot meet demands

b. Used to provide heat to the conditioned space when the heat pump is in a defrost mode

c. Used to provide 100% of the heat during emergency operation

III. Managing energy resources

A. Fossil fuels--Provide a relatively uniform heat output under all operating conditions

B. Radiant solar energy--Will vary in predictable ways with changing weather conditions

C. Reverse cycle heat pump--Will vary its capacity with changing temperatures and humidity conditions

(NOTE: During the heating mode the capacity is reduced in proportion to the drop in outdoor temperature.)

D. Electric resistance heat--Provide a uniform heat output under constant voltage conditions

IV. Calculating solar requirements

A. Requirements

1. Efficient utilization of established data on selected collector plates

2. Adjustment for changes in collector effective solar incidence for selected area

3. Identification of specific structure heat loss to be replaced by solar radiant heat

4. Established data on method of storing collected solar heat

V. Calculating solar system output

A. Capacity of the solar radiant heat collection system--Is based on the net Btu output of each collector panel for each winter month for the selected location

B. Net output rating for each month reflects

1. Insolation--Radiant energy that falls on the panel

2. Efficiency--The proportion of radiant energy which the collector can transform into usable Btu's
3. Angle of incidence--Angle of solar altitude
4. Collector tilt recommended--Angle with the horizon
5. Monthly ambient temperatures--Heat loss from the collector panel
6. Percent sunshine--Proportion of clear to overcast weather for the month
7. Local haze--Air pollution factors

C. Net monthly Btu output is utilized to

1. Calculate the required collector surface needed for a specific application
2. Calculate operating cost
3. Determine seasonal performance factors compared to resistance heat and other heating sources
4. Divide the heating load between radiant energy and reverse cycle heat pump operation
5. Permit a panel-by-panel modification of the initial design with measurable effect on month-by-month energy consumption
6. Permit a wide range of acceptable balances between initial cost and operating efficiency

VI. Storing energy for a solar assisted heat pump

A. Recommended capacity--Limited to practical, meaningful proportions

B. Design considerations

1. Designed principally to cover the daily requirements of the heat pump for supplementary heat below the first balance point

2. Designed to limit the need for resistance heat required below the balance point operation

    (NOTE: Use of resistance heat below the first balance point can account for 1/3 to 1/2 of total winter heating cost in conventional heat pump systems.)

3. Designed to make a most important contribution to operating economy by substituting low cost stored solar energy for electric resistance heat

VII. Availability of system components

A. Solar components - mechanical

1. Liquid solar collector panels

a. Flat plate collectors--Medium temperature collector available from solar dealers, distributors, solar supply firms and some heating/air conditioning distributors and their dealers

(NOTE: Fedders Air Conditioning Distributors stock and sell liquid cooled, double glazed solar collectors.)

b. Vacuum tube collectors--High temperature collector generally available from franchised solar dealers and distributors only

(NOTE: Some solar parts and supply firms are also approved distributors for such items as vacuum tube and rough type concentractor collectors.)

2. Hydronic solar heating coil units (Transparency 1)--Are available from local plumbing/heating wholesalers, solar supply firms and air conditioning/refrigeration parts supply companies

(NOTE: Fedders Corporation Distributors and Dealers market hydronic coil units to match their Fedders solar assisted heat pump systems.)

3. Liquid-to-liquid heat exchangers--available from solar equipment dealers and distributors, heating/air conditioning distributors, air conditioning/refrigeration parts and supply companies and solar parts jobbers

   (NOTE: All heat exchangers should be the type and size specified for the selected equipment.)

4. Circulator pumps--avilable from local plumbing/heating wholesalers and solar parts and supply companies

5. Motorized two-position diverter valves--available from solar equipment distributors and dealers, solar parts and supply companies, local air conditioning/refrigeration wholesalers and plumbing jobbers

6. Other hydronic components, valves, fittings, expansion tanks, pipe, etc.--available from solar equipment distributors, plumbing firms, air conditioning/refrigeration parts and supply companies and solar parts and supply firms

7. Thermal storage tanks--available from local fabricators, solar equipment dealers and distributors, solar parts and supply firms, and companies specializing in storage tanks

   (NOTE: Selection of the thermal storage tank should be based on size designed for and temperature limit of stored transfer fluid.)

B. Solar components - electrical

1. Differential thermostat controller for solar energy collected and placed in storage--available from solar dealers and distributors and solar parts supply companies only

2. Control sensors--available from solar parts supply companies and solar equipment distributors only

3. Solenoid operator valves, relays, switches, etc.--available from plumbing/heating wholesalers, solar parts supply companies and air conditioning/refrigeration wholesalers

C. Heat pump system components - mechanical--available from heating and air conditioning dealers and distributors and air conditioning/refrigeration parts and equipment jobbers and supply companies

1. Indoor coil assembly (Transparency 1)

2. Outdoor coil and compressor assembly (Transparency 1)

3. Reversing valves

4. Thermostatic expansion valves

5. Capillary tubes

6. Valves, piping

D. Heat pump system components - electrical--available from air conditioning and heating dealers and distributors

1. Indoor fan motors (Transparency 1)

2. Outdoor unit fan motor and compressor (Transparency 1)

3. Solar assisted heat pump system control package--specially designed control system available from solar component manufacturers, solar supply companies and limited air conditioning equipment distributors and dealers

(NOTE: Fedders Air Conditioning Distributors offer a control package for their solar assisted heat pump system.)

4. Differential thermostat controller for the solar energy collection system--generally available from solar supply companies, solar dealers and solar distributors only

5. Electric resistance strip heaters (Transparency 1)--available from air conditioning and heating dealers and distributors

6. Indoor and outdoor thermostats, relays, solenoid coils, etc.--available from air conditioning and heating dealers and distributors and air conditioning/refrigeration parts and supply companies

VIII. Heating phases of a solar assisted heat pump (Transparency 2)

A. Integrated four-phase heating

1. First heat phase--The solar subsystem should have the capacity to supply needed heat between 68°F to 47°F except in periods of overcast or cloudy weather

   (NOTE: This temperature will cover a high percentage of all daylight winter hours.)

2. Second heat phase--At 47°F the solar subsystem is turned off by some manufacturers and the reverse cycle heat pump is turned on; this mode will continue until the first balance point is reached

   (NOTE: The first balance point is generally calculated between 35°F and 28°F.)

3. Third heat phase--When the first balance point is reached, the solar subsystem is again turned on to provide auxiliary heat to support the capacity of the heat pump, thus, eliminating the normal use of high cost resistance heat strips

4. Fourth heat phase

   a. Generally set at the second balance point

   b. Brings on first stage of electric resistance heat

   c. Turns off the solar subsystem

   d. Continues operation of the reverse cycle heat pump

      (NOTE: Additional heat strips should be cycled on as needed by outdoor thermostats set to support third and fourth balance points.)

5. Special overriding conditions (Transparency 2)

   a. First heat phase--Will be bypassed if the solar storage temperature is 100°F or below and the outdoor temperature is between 68°F and 47°F

   b. Third heat phase--The third phase will be bypassed if solar storage temperature is below 100°F when the system is operating at or below the first balance point

   c. Automatic control switching--Will revert the system to first heat phase regardless of outdoor temperature if the solar storage temperature reaches 180°F

   (NOTE: This type of flexibility, in overriding control modes, assures owner comfort and the best economical use of solar assisted heat pump systems.)

IX. Summer operation of a solar assisted heat pump system

A. Heat pump system

1. Indoor thermostat system switch is adjusted to the cool position

2. The heat pump performs as an air conditioner only

B. Solar subsystem

1. Used to heat water in hotwater tanks

2. Used to heat water in swimming pools

(NOTE: An expansion tank with pressurized diaphragm should be installed in the collector loop along with a pressure relief valve to handle possible excess summer heat buildup.)

X. Domestic hotwater preheat loop (Transparency 3)

A. Piping circuit

1. Cold supply water is circulated through a heat exchanger in the thermal storage tank

2. Heated water from the heat exchanger is piped into the cold water inlet of the domestic hotwater tank

3. Hot water from the domestic tank is piped through a mixing valve, then to use points

   (NOTE: The solar system can provide most of the hotwater needs during winter heating and should provide all of it during nonheating periods.)

XI. Function of collector loop components (Transparency 4)

A. Solar collector panels--Converts solar radiation into thermal energy

B. Circulator pump--Pumps the heat transfer fluid through the collectors and heat exchanger

C. Heat exchanger--Serves as a means of transferring the collected solar energy from the collector loop to the storage/terminal loop

   (NOTE: The heat exchanger is a very critical component and should be replaced with the same type and size in case of failure.)

XII. Functions of storage/terminal loop components (Transparency 5)

A. Circulator pump

   1. Is activated each time the collector loop pump is running

   2. Pumps heated transfer fluid from the thermal storage tank through the heat exchanger to the hydronic coil and back to storage during the first heat phase mode

   3. Pumps heated transfer fluid through the heat exchanger and back to storage during the second heat phase

   4. Pumps heated fluid from storage to the hydronic coil and back to storage if the collector loop pump is off and the heating thermostat calls for heat

      (NOTE: This action is bypassed if storage temperature is below 100°F.)

B. Thermal storage tank

1. Provides storage capacity to meet the design function of the solar subsystem during heating operations

2. Provides means of preheating water for the domestic hotwater tank

3. Provides storage for solar heated water during nonheating periods

C. Hydronic coil--Provides a means for the use of hot water to heat air from the conditioned space

D. Motorized 2-position diverter valve

1. Directs hot water directly to the hydronic coil and then to thermal storage during first heat phase

2. Directs hot water directly to the thermal storage tank during second heat phase

3. Directs hot water directly from thermal storage during periods when the collector loop pump is off and heat is called for by the control system

4. Directs heated water from storage to the hydronic coil if thermal storage temperature reaches 180°F and the indoor thermostat calls for heat

(NOTE: An automatic control sequence will cause the system to revert to direct solar heating when the 180°F temperature is reached regardless of which heating phase the system is in.)

E. Bypass valve

1. A globe valve installed in the discharge side of the hydronic coil

2. Adjusted to divert to storage the difference between total fluid flow through the storage/terminal loop and the designed Gpm flow rate of the hydronic coil

(NOTE: In installations where the flow rate through the storage/terminal loop is equal to or less than the Gpm rate of the hydronic coil, the bypass valve may be omitted.)

XIII. Functions of the heat pump components (Transparency 6)

A. The heat pump outdoor unit--Absorbs heat from the outdoor air during the heating mode and transports the collected heat to the indoor coil unit

B. Indoor coil unit--Heat absorbed in the outdoor unit is transferred from the indoor coil to the circulating conditioned space air

C. Electric resistance heaters--Provide auxiliary heat source to supplement the heat pump and solar system

D. Indoor air handler--Provides housing and support for the indoor coil, blower motor, fan and the resistance heater strips

XIV. Calculating heating requirements for a solar heat system

A. Heat gain/heat loss study--An accepted method of completing a heat gain/heat loss study of any residential structure is to use the NESCA Manual "J" Procedures on a NESCA J-1 Form

(NOTE: This should be completed by an individual trained in using the J-1 Form.)

XV. Designing the solar assisted heat pump system

A. Should be designed by

1. A trained solar engineer

2. A trained solar technician

3. Trained distributor engineer

4. Trained factory representative

XVI. Net monthly output ratings of collectors (Transparency 7)

A. Rated in thousands of Btu's per hour (MBTU)

XVII. Information provided by the monthly output data sheet on collectors

A. Degree north latitude

B. Location of different installation sites

C. Collector tilt recommended for each location

D. Information on output for a seven month period

(NOTE: This covers a normal heating season.)

XVIII. Physical orientation of flat plate collectors

A. Priority consideration should be given to the change of angle in the sun's path of travel from winter maximum to summer maximum

XIX. Collector tilt and orientation (Transparency 9 and 10)

A. Collector tilt (Transparency 9)

1. The collectors should be tilted above the horizon 12° to 15° more than the degree of latitude at the installation site

(NOTE: A tilt of more than 15° can result in significant loss in collector output.)

B. Collector orientation (Transparency 10)

1. Collectors can face from 15° to 20° east or west of true south without significant loss of output in most flat plate collectors

(NOTE: Care should be used in locating true south with a hand compass. If in doubt, check the plot map on file in the local tax office.)

XX. Flat plate collector installation precautions (Transparency 11)

A. Collectors should be mounted on roofs with spacers that will permit water to drain off and to provide ventilation under the panels to dry roof materials

B. Protect all metal parts from electrolic action by insulating dissimilar metals from direct contact with each other

(NOTE: A good example of this is steel lag bolts inserted through holes in aluminum collector panel mounting casing.)

XXI. Methods of circuiting collectors (Transparency 12)

A. Six to seven collectors can be connected in series to form a group

B. Series connected groups of collectors can be arranged in parallel to form an array

(NOTE: Groups of collectors may also be referred to as a "bank".)

C. The number of collectors in each group should be the same to insure uniform flow rates

XXII. Sizing copper pipe in a solar system (Transparency 13)

A. Tubing size--Determined by the volume of fluid to be moved and the "equivalent length" of the circuit

(NOTE: The linear length of the circuit as measured in feet plus an additional allowance for each elbow, tee fitting, and valve included in the circuit.)

B. Equivalent feet of tubing for fittings (Transparency 13)

1. The total length of tubing designed into each collector loop should represent allowances for loss due to fittings and valves in the circuit

XXIII. Collector loop pump and pipe sizes (Transparency 14)

A. A properly sized pump--Should maintain the designed flow rate for a bank of several collectors

B. The collector loop piping--Should be selected to match the designed capacity of pump and loop

(NOTE: Refer to Transparency 13 and 14 for guides in selection of pipe fittings and pump.)

XXIV. Expansion tank (Transparency 15)

A. Purpose--To handle changes in pressure and volume which occur with changes in fluid temperature in closed loop systems

B. Type--Should be of the pressurized diaphragm type selected to handle the type of transfer fluid used

C. Volume--An expansion tank with an acceptance volume of 35, a capacity equal to 35 percent or more of the total fluid volume in the collector loop, should be selected

D. Sizing the expansion tank (Transparency 16)

   1. Calculate the fluid volume of the individual components in the collector loop and add them together

   2. Calculate the fluid volume in the interconnecting tubing

   3. Add these values together to get the total internal volume

      (NOTE: Refer to tables in Transparency 16) for formulas in calculating the above volumes.)

XXV. Components common to collector loop (Transparency 17)

A. Balancing valve--Located between the collector panels and the circulator pump to throttle fluid flow the the desired rate

B. Pressure relief valve--Located where pop-offs can be drained into a container

C. Automatic float type air vent--Located at the high point of the collector group return manifold

D. Check valve--Located in the collector return line above the heat exchanger to prevent convection back flow at night

   (NOTE: Cool temperatures in the collector panels can cause thermal siphoning of heated transfer fluid from the storage tank.)

E. Drain valve--Located in the line to the collectors to drain the collector loop supply side

F. Drain and fill valve--Located down stream from the pump; used to fill and/or drain the collector loop

XXVI. Collector loop transfer fluid antifreeze

A. Purpose--Used to prevent freezing or boiling of water in the collector loop

B. Ethylene glycol mixture (Transparency 18)

1. A 50%-50% solution of water and ethylene glycol is widely used in solar systems

   (NOTE: A 50-50 mixture of water and ethylene glycol will generally provide freeze protection to munus 32°F.)

2. Local codes should be followed in the selection of the heat transfer fluid

   (NOTE: The type of transfer fluid selected will generally determine the type of heat exchanger that will be approved also.)

3. A margin of protection at least 15 degrees below the lowest temperature recorded for the site area should be provided

4. Correct solution mixtures should be selected for the application site using the formulas listed in Transparency 18

5. Ethylene gloycol muxtures should maintain a pH factor within a range of 6.0 and 8.5 in a scale where 7 is neutral

6. The pH factor can be tested by immersing a strip of chemically treated paper in the collector loop solution and comparing the resultant color change against a color chart

   (NOTE: pH test paper can be purchased from a local chemical or medical supply house for this purpose.)

7. Chemicals to restore the transfer fluid to the correct pH level can be obtained from stores that sell supplies for swimming pools

   (NOTE: There are a number of antifreeze solutions available that contain inhibtors and buffers which maintain pH factors over long periods and minimize other chemical effects on the transfer fluid.)

XXVII. Filling the collector loop with transfer fluid

A. The collector loop--Should be filled according to the equipment manufacturer's installation instructions

XXVIII. The collector loop heat exchanger (Transparency 17)

A. Function

1. To serve as a contact vessel between the storage loop and collector loop heat transfer fluids

2. To protect the storage/terminal loop water from contact with the toxic transfer fluid

(NOTE: Most codes will require a double wall heat exchanger with external venting.)

XXIX. The storage/terminal loop components (Transparency 19)

A. Thermal storage tank--Follow recommendations of the equipment manufacturer in selecting a storage tank

B. Expansion tank--Used to handle changes in pressure and volume which occur with changes in fluid temperature

(NOTE: The expansion tank should be installed between the storage and hydronic coil and heat exchanger.)

C. Hydronic solar heating coil

1. Installed down stream of the indoor blower

2. Functions on two levels in the heating mode

a. As the prime source of heating at outdoor temperatures above 47°F

b. In support of the heat pump below the first balance point

3. Output of the hydronic coil can be figured by

a. Determining the temperature of the air supplied to it by the indoor coil of the heat pump.

This can be computed from the following formula:

$$70°F + \frac{\text{BTU Output of Heat Pump at Operating Condition}}{1.08 \times \text{cfm}}$$

b. Btu output of sample heat pumps (Transparency 20)

c. When the temperature of air entering the coil has been figured, consult Transparency 20 to find the output of the hydronic coil

d. Output of sample hydronic coils, MBTU (Transparency 21)

XXX. Pipe sizing for storage/terminal loops

A. Pipe size selection

1. For teminal loop (Transparency 22)

2. For storage loop (Transparency 22)

(NOTE: Storage loop pipe is sized for the full flow portion of the loop.)

XXXI. Domestic hotwater loop components (Transparency 3)

A. Domestic hotwater tank

1. Inlet water to tank is preheated water from the heat exchanger installed in/wrapped around the thermal storage tank

(NOTE: Capacity for preheating water for domestic use is provided in the sizing procedures for the solar assisted heat pump energy collection and storage.)

2. Equipped with one or two electric resistance heating elements to boost the tank temperature to designed setting

3. Will generally be a stone or glass lined tank equipped with one or more anode rods to control corrosion

B. Heat exchanger (Transparency 23)

1. Preheats the cold water supply before it enters the domestic tank

2. Will generally be of the double wall, vented type to meet local codes that require two metal walls between any toxic fluids and the system's potable water

   (NOTE: Local codes will, in most cases, require a vent to the outside of the tank to indicate when there is a leak in either wall of the exchanger.)

3. This type of heat exchanger is also called a "tankless heater".

C. Mixing valve

1. A three port valve that is equipped with an internal thermostat and mixing chamber

2. Hot water from the storage tank enters one end of the valve

3. Cold water supply enters one side of the valve

4. Tempered hot water leaves one end of the valve

5. Leaving water temperature is determined by the mixing valve setting

   (NOTE: Most mixing valves are adjustable from 110°F to 160°F with an average setting of 120°F - 140°F.)

D. Check valve--Installed between the cold water supply line and the mixing valve to eliminate the possibility of back flow into the supply water in case of pressure loss

(NOTE: This is not a standard type check valve, but a positive shutoff, back flow preventer valve.)

E. Gate valve--To provide a means of isolating the domestic hotwater tank from the thermal storage

F. Auxiliary water heater element--Electric heating element to insure sufficient hot water regardless of thermal storage temperature

G. Cooling valve--Adjustable mixing valve may be required by local codes between the supply water to thermal storage and the return line to domestic water heater to prevent water in the domestic tank from reaching scalding temperatures

(NOTE: This would be the same type valve used to temper the hot water to the house, usually set at about 140°F.)

XXXII. The system control package

A. Components

1. Main control panel (Transparency 24)

a. Controls operation of various relays

b. Functions with various thermostats to switch system operations from one mode or action to another

2. Upper operating liquid storage thermostat (Transparency 24)

a. Switches system to solar heating regardless of outdoor temperature when thermal storage reaches 180°F

3. Lower operating liquid storage thermostat (Transparency 24)

a. Switches control to heat pump operation if storage temperature falls to 100°F on first stage heat

b. Switches to electric heat below the balance point on second stage heat

(NOTE: On some systems this action is controlled through a time delay relay.)

4. Upper limit liquid storage thermostat (Transparency 25)

a. Shuts down collector loop pump when storage temperature reaches 200°F to prevent a higher rise in storage temperature

5. Outdoor thermostat (Transparency 25)

   a. Cycles the heat pump on the replace solar heat when outdoor ambient temperature falls to a preset point

   b. Returns system to solar heat when the outdoor ambient rises above the preset point

      (NOTE: If solar storage is 100°F or less, the controls will override the solar heat return mode and remain in heat pump operation.)

6. Balance point thermostat (Transparency 25)

   a. Cylces the auxiliary electric strip heaters on, if needed, to satisfy indoor heat requirements

      (NOTE: The use of solar heat and resistance heat at the same is generally not desired and is prevented through use of a time delay interlock relay.)

7. Differential temperature thermostat (Transparency 25)

   a. Controls collector loop circulator pump on and off cycle

   b. Equipped with a minimum of two control sensors; installed in one collector panel and the thermal storage tank

      (NOTE: Control sensors may be of the immersion or clamp-on type.)

8. Time delay solar interlock relay

   a. Prevents the collector loop circulator pump from operating at the same time as the electric strip heaters

      (NOTE: Time delay between the demand for strip heat and cycling on of the heaters will vary according to timer selection, generally less than 10 minutes.)

XXXIII. System operation analysis (Transparency 26)

A. System functions and temperature ranges

1. Diagram No.--Indicates simulated position of diagram switches

2. Storage tank temperatures--Simulates system modes that are possible at given thermal storage water temperatures

3. Outdoor temperatures--Simulates system modes that are possible at given outdoor temperatures

4. 1st stage--Indicates that the indoor thermostat could be calling for heat in the conditioned space

5. 2nd stage--Indicates that the temperature in the conditioned space has fallen below the setting of the first stage point

6. Hydronic coil--Indicates when the hydronic coil is used for total heat source and when it is used to supplement heat pump capacity

7. Heat pump--Indicates when the heat pump is used to supplement solar heat or provides the total heat needed

8. Electric heat--Indicates when electric heat is used to supplement the heat pump capacity

(NOTE: Most utilities and some local codes require that sufficient electric heat be installed to handle the heat requirements of the structure in case of emergency.)

XXXIV. Wiring diagrams

A. Solar system (Transparency 27

1. 115/24 VAC transformer--Provides low voltage for control circuit components

2. Terminal strip--Connection point for indoor thermostat and control wiring

3. Balance point relay (RBP)--Controlled by contacts on the balance point thermostat

4. Indoor blower relay (RIB)--Controlled by contacts on the solar heat relay

5. Heat relay (RH)--Circuit includes contacts in the

   a. Indoor thermostat

      (NOTE: A call for heat will complete the thermostat circuit for first stage heat.)

   b. Upper liquid storage operating thermostat

   c. Storage temperature relay

   d. Outdoor thermostat

6. Solar heat relay (RSH)--Circuit includes contacts in the

   a. Indoor thermostat--First stage heat

   b. Storage temperature relay--(RST)

   c. Solar interlock relay--(RSI)

   d. Balance point relay--(RBP)

   e. Outdoor thermostat--(TOD)

   f. Liquid storage upper operating thermostat--(TUO)

7. Electric heat relay (REI)--Circuit includes contacts in the

   a. Indoor room thermostat--Second stage heat

   b. Balance point relay--(RBP)

   c. Time delay relay--(TRD)

8. Solar interlock relay (RSI)--Circuit includes contacts in the
    a. Indoor room thermostat--Second stage heat
    b. Balance point relay (RBP)
    c. Time delay relay (TRD)
9. Storage temperature relay (RST)--Circuit includes contacts in the
    a. Lower liquid storage operating thermostat (TLO)
10. Differential thermostat relay (RDT)--circuit includes contacts in the
    a. Differential thermostat sensor control relay circuit
11. Collector loop pump (PCL)--Circuit includes contacts in the
    a. Upper liquid storage limit thermostat (TUL)
    b. Differential thermostat relay (RDT)
12. Storage terminal loop pump (PSL)--circuit includes contacts in the
    a. Differential thermostat relay (RDT)
    b. Solar heat relay (RSH)
13. Hydronic control valve (VH)--Circuit includes contacts in the
    a. Solar heat relay (RSH)
14. 115V, 60 HZ power supply to solar control panel--Sizing, selection and installation of all power wiring will, in most cases, require a licensed electrician to meet local codes

XXXV. Solar assisted heat pump system (Transparency 28)

A. Compressor heater--Connects to L1 and L2 for continuous operation

(NOTE: This heater is used to provide heat to the compressor crankcase to prevent liquid refrigerant buildup in the oil.)

B. Compressor--Circuit includes contacts in the

1. Compressor contactor
2. Starting relay

(NOTE: The starting relay is an optional component not used on all compressors.)

C. Starting relay--Circuit includes

1. Coil--Connected parallel with the compressor start winding
2. Start capacitor--Connected in series with the compressor start winding between L1 and the relay contacts
3. Relay contacts--Connected between the start capacitor and the relay coil

(NOTE: One end of the contacts may also be connected directly to the compressor start winding terminal.)

D. Run capacitor (RC)--Connected in series with the compressor start winding between the run terminal and the start winding terminal

(NOTE: Line side of the run capacitor will occasionally be connected to the line side of a start capacitor or run directly to line.)

E. Outdoor unit fan motor (OFM)--Circuit includes contacts in the

1. Compressor contactor circuit (CC)
2. Defrost timer (DT)

(NOTE: The outdoor unit fan motor is generally a capacitor run motor with the capacitor connected in series with the start winding.)

F. Defrost relay (RD)--Circuit includes contacts in the
   1. Compressor contactor (CC)
   2. Defrost timer (DT)

G. Reversing solenoid--Circuit includes contacts in the
   1. Heat relay (RH)
   2. Defrost relay (RD)

H. Defrost timer motor (DTM)--Circuit includes contacts in the
   1. Compressor contactor (CC)

I. Heat relay (RH)--Circuit includes contacts in the
   1. Indoor room thermostat
   2. Upper liquid storage operating thermostat (TUO)
   3. Storage temperature relay (RST)
   4. Outdoor thermostat (TOD)

J. Compressor contactor (CC)--Circuit includes contacts in the
   1. Loss of charge protector (LCP)

      (NOTE: This switch is often referred to as a low pressure switch.)

   2. Indoor room thermostat
   3. Heat relay (RH)

K. Electric heater circuits
   1. Heater number one (HTR 1)--Circuit includes contacts in the
      a. Electric heat relay (RE 1)
      b. Temperature limit control (TLC)

2. Heater number two (HTR 2)--Circuit includes contacts in the
    a. Electric heat relay (RE 2)
    b. Temperature limit control (TLC)

    (NOTE: Each heater is also protected by a fusible link and fused disconnect.)

3. Heater number three (HTR 3)--Circuit includes contacts in the
    a. Heating relay (RE 3)
    b. Temperature limit control (TLC)

4. Heater number four (HTR 4)--Circuit includes contacts in the
    a. Heat relay (RE 3)
    b. Temperature limit control (TLC)

(NOTE: Most electric heater circuits require a separate 208/230 VAC 1 phase power supply installed by or under the supervision of a licensed electrician to meet local wiring codes.)

L. Electric heater control circuit

1. Electric heater relay (RE 1)--Circuit includes contacts in the
    a. Indoor room thermostat
    b. Balance point relay (RBP)
    c. Time delay relay (TDR)
    d. Auxiliary heater control (AHC)

2. Electric heater relay (RE 2)--Circuit includes contacts in the
    a. Heater relay (RE 1)
    b. Auxiliary heater control (AHC)
    c. Outdoor thermostat (A)

3. Electric heater relay (RE 3)--Circuit includes contacts in the
    a. Heater relay (RE 2)
    b. Outdoor thermostat (B)

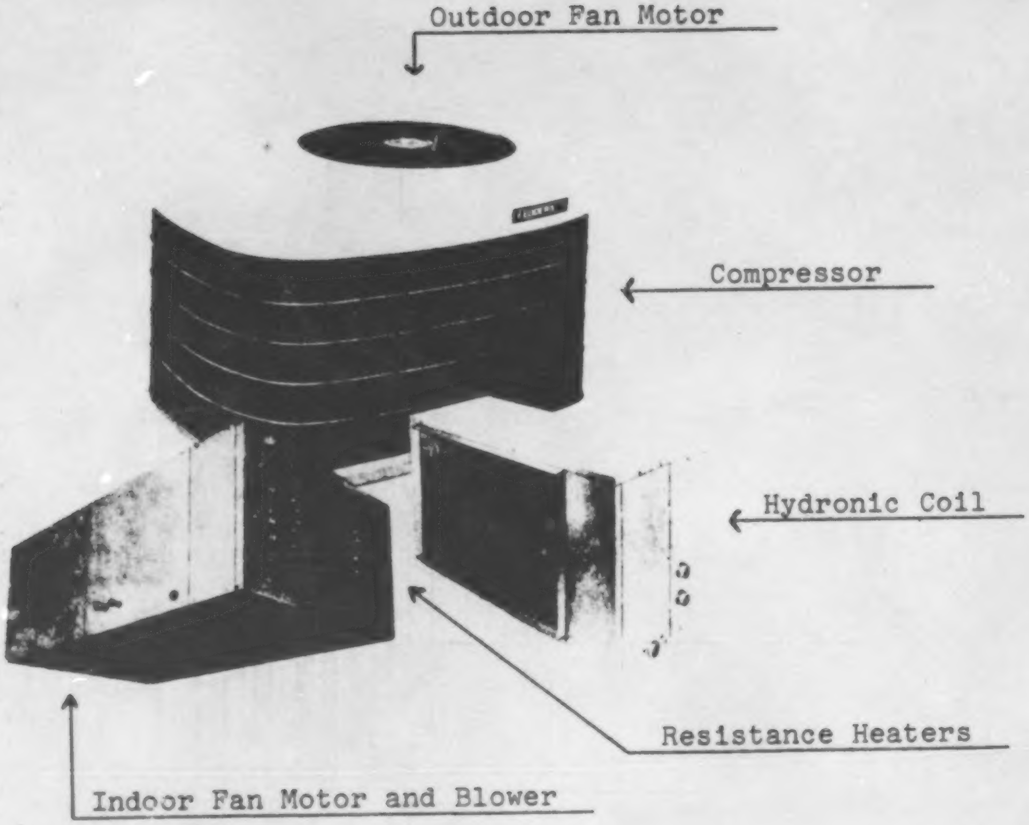
M. Indoor blower motor (IBM)--Circuit includes contacts in the
    1. Indoor blower relay (RIB)

(NOTE: The indoor unit requires a separate 115 VAC power supply that should be installed by or under the supervision of a licensed electrician.)

N. Indoor blower relay (RIB)--Circuit includes contacts in the
    1. Indoor room thermostat

(NOTE: Power for the 115/24 volt transformer is generally supplied by the indoor unit power supply.)

SOLAR ASSISTED HEAT PUMP COMPONENTS



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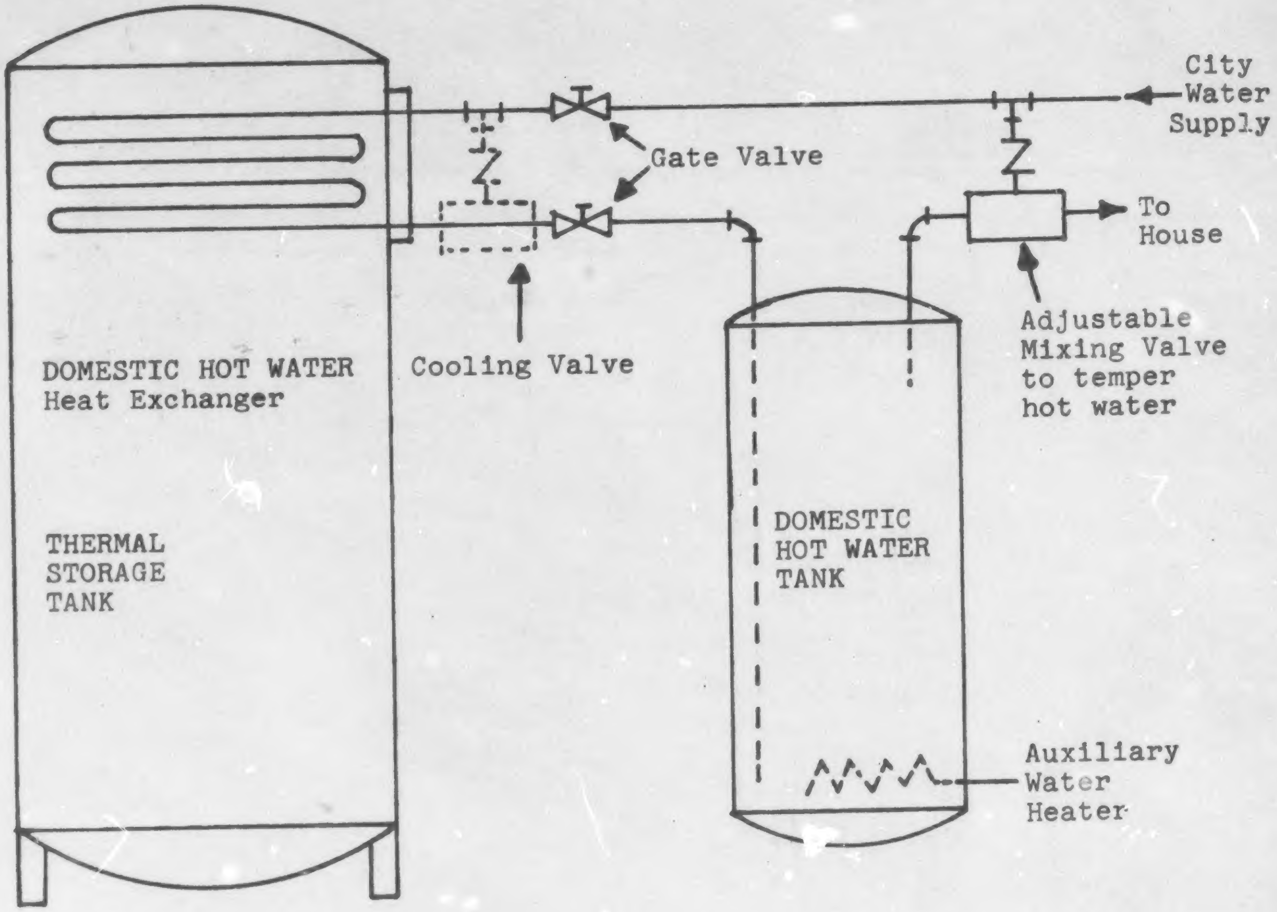
1132

SEQUENCE OF HEATING MODES OF THE SOLAR-ASSISTED HEAT PUMP

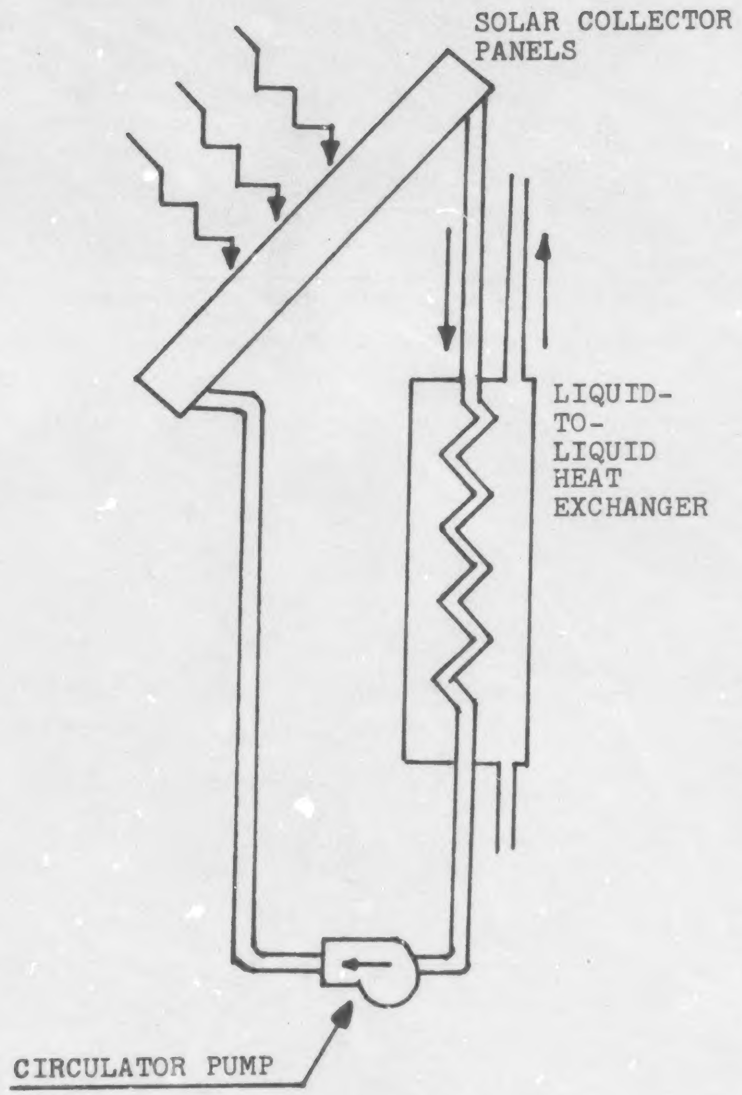
<table>
<tr><td>65° to 47°F
(First Heat Phase)</td><td>Radiant Solar Energy</td></tr>
<tr><td>47°F to
First Balance Point
(Second Heat Phase)</td><td>Heat Pump on Reverse Cycle Operation</td></tr>
<tr><td>Below First Balance Point
(Third Heat Phase)</td><td>Reverse Cycle Operation
Plus
Radiant Solar Energy as Supplemental Heat</td></tr>
<tr><td>Below First Balance Point After Overcast Weather
(Fourth Heat Phase)</td><td>Reverse Cycle Operation
Plus
Resistance Heaters</td></tr>
<tr><td colspan="2">OVER-RIDE CONDITIONS
Storage temperature is less than 100 degrees --- system advances to the next heat phase automatically
Storage temperature is 180 degrees F or higher --- system reverts to first heat phase . . . radiant solar energy --- despite outdoor temperatures</td></tr>
</table>

DOMESTIC HOT WATER PREHEAT LOOP

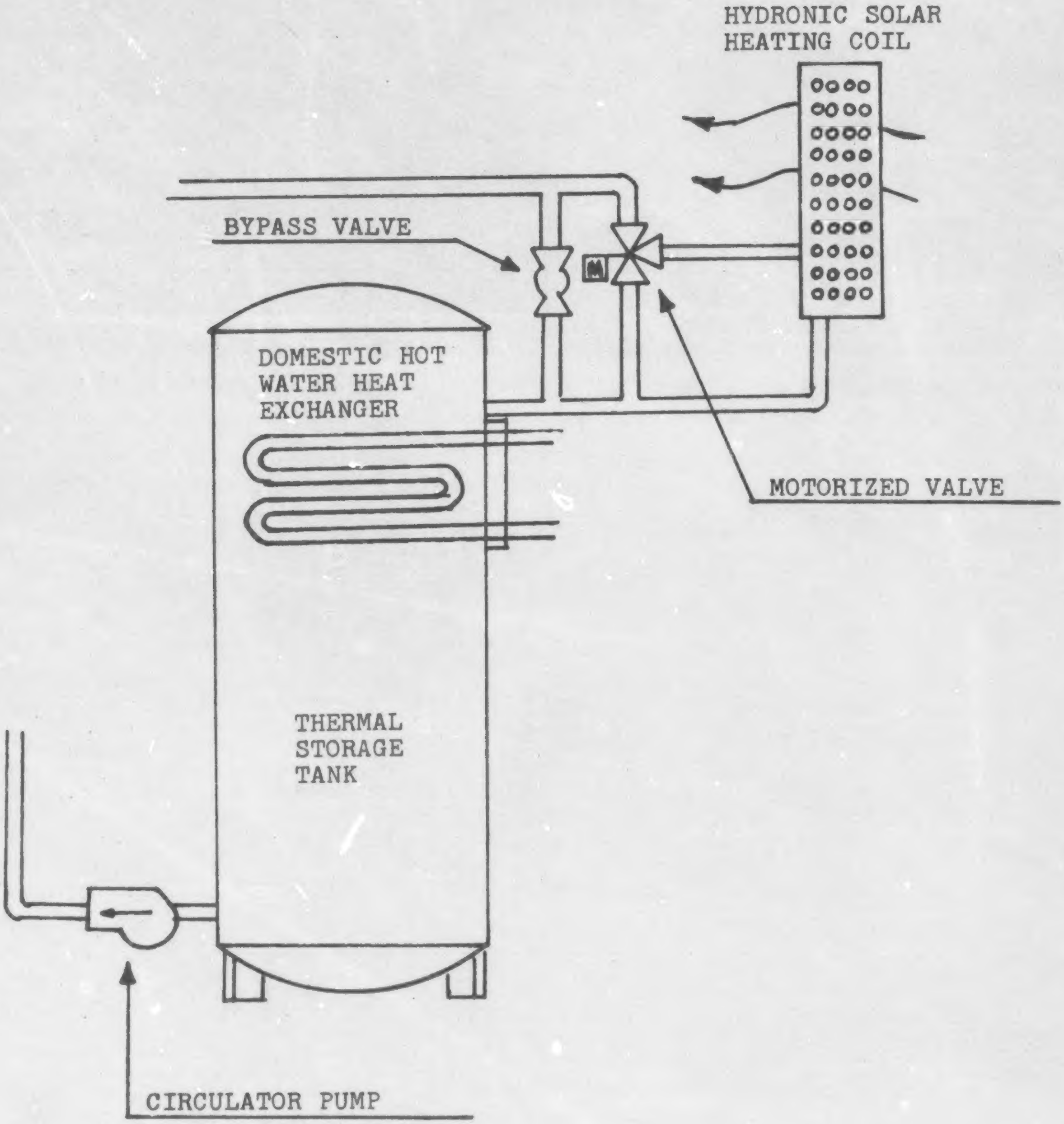


1134

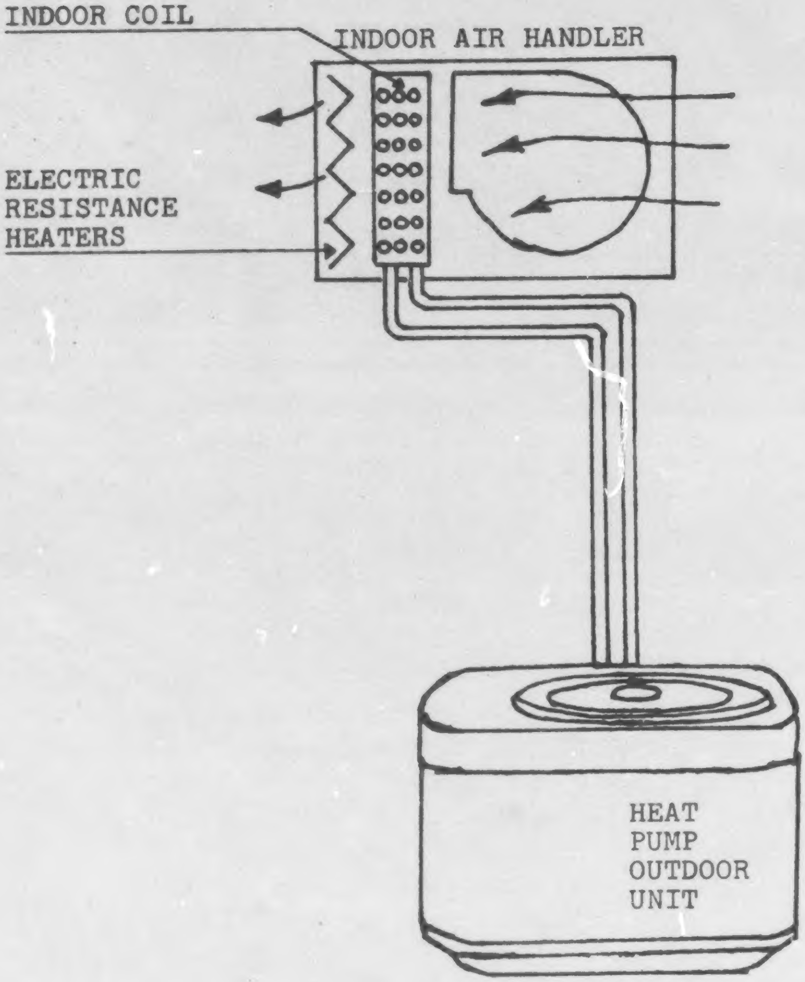
COLLECTOR LOOP



STORAGE/TERMINAL LOOP



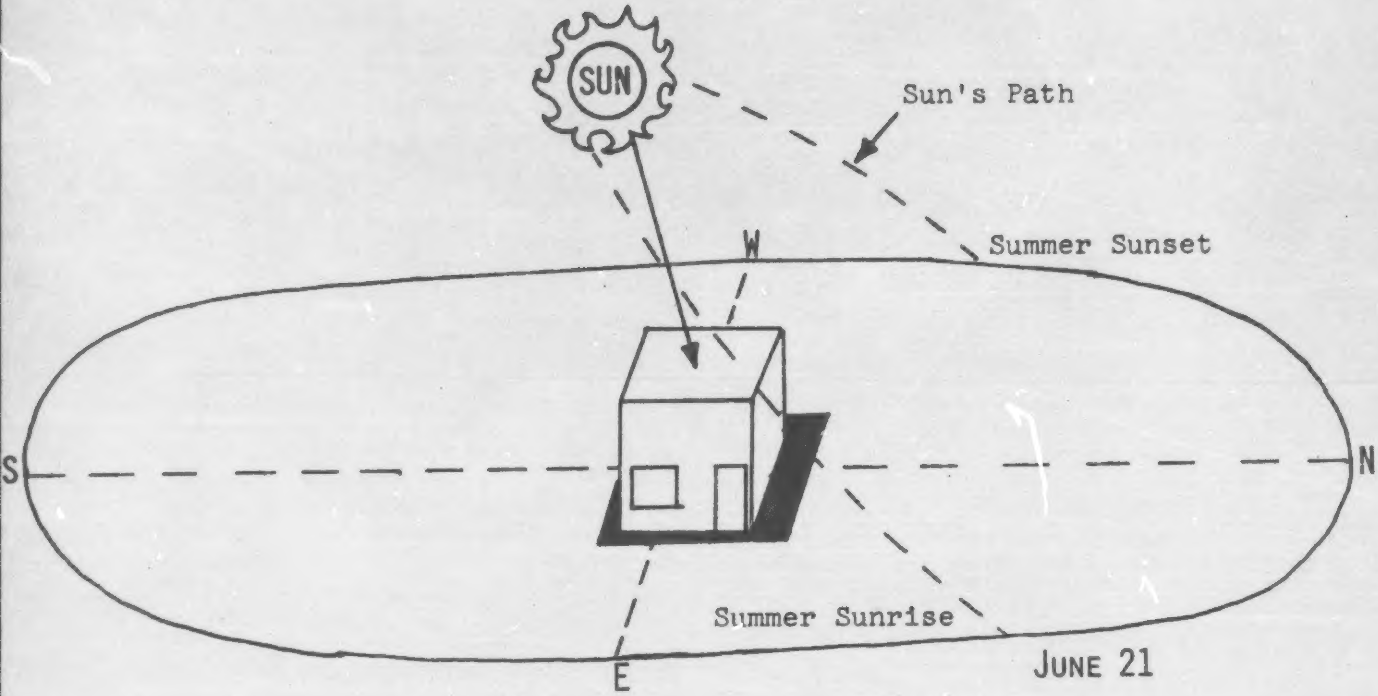
HEAT PUMP LOOP

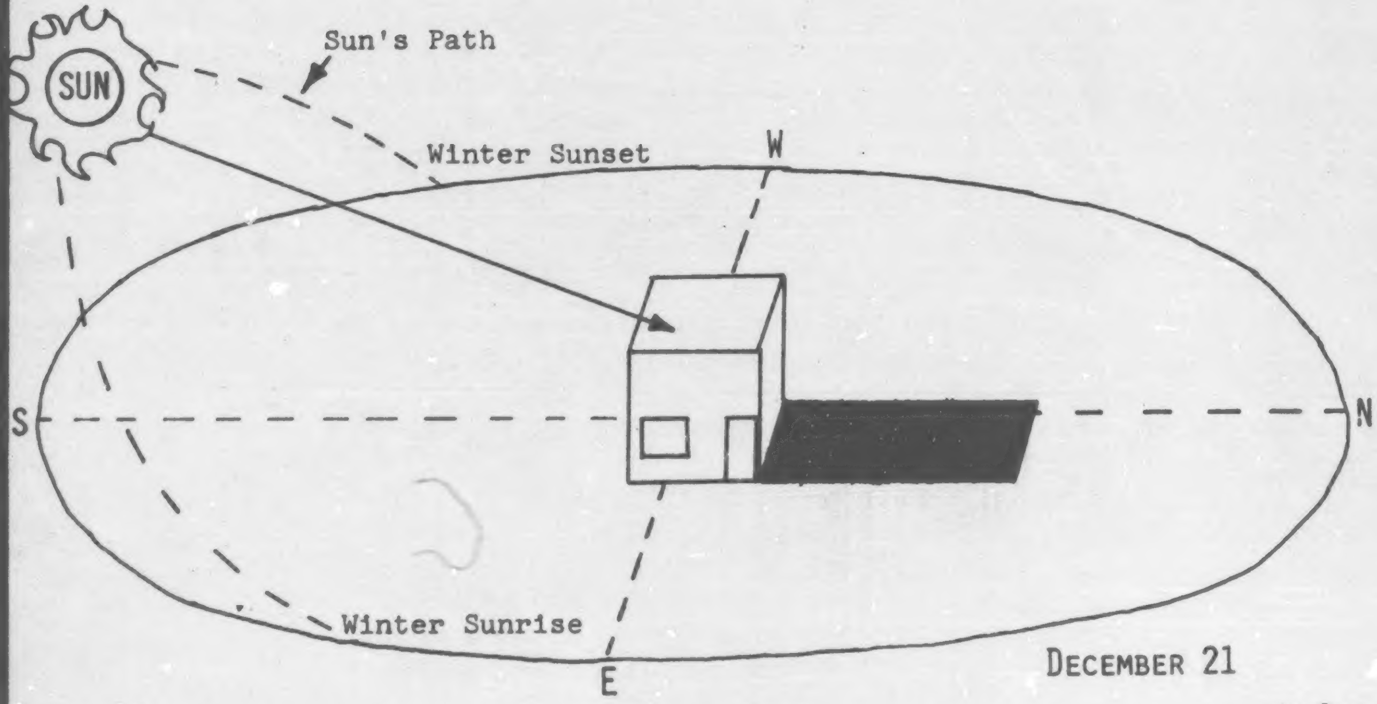


MONTHLY OUTPUT, COLLECTOR PANEL - MBTU

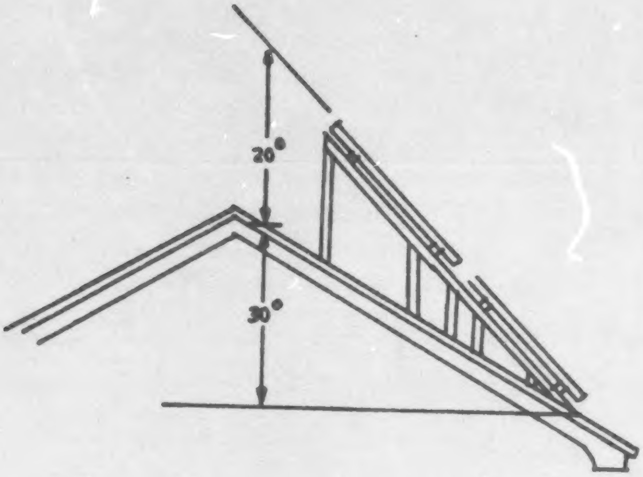
°Latt. North	Location	Collector Tilt°	Oct.	Nov.	Dec.	Jan.	Feb.	March	April
35.1	Albuquerque, New Mexico	50°	588.5	464.5	457.4	488.6	471.5	558.7	505.0
33.1	Atlanta, Georgia	48°	407.0	314.2	265.8	302.0	292.3	351.1	341.8
25.1	Brownsville, Texas	40°	485.3	328.0	338.5	379.9	341.6	375.9	330.3
46.1	Caribou, Maine	61°	246.0	113.6	155.4	199.3	273.3	365.3	240.4
29.1	Gainesville, Florida	44°	408.8	378.9	339.2	384.5	389.2	431.9	397.6
34.1	Little Rock, Arkansas	49°	417.6	286.8	251.9	231.4	256.4	323.2	398.4
36.1	Nashville, Tennessee	51°	396.3	253.4	212.6	181.8	232.7	292.3	303.2
45.1	Saint Cloud, Minnesota	60°	289.2	174.2	184.4	277.9	328.2	372.9	280.3
47.1	Seattle, Washington	62°	186.2	84.3	65.3	72.0	120.7	220.6	233.2

SUN'S PATH


SUN
Sun's Path
W
Summer Sunset
S
N
Summer Sunrise
E
JUNE 21

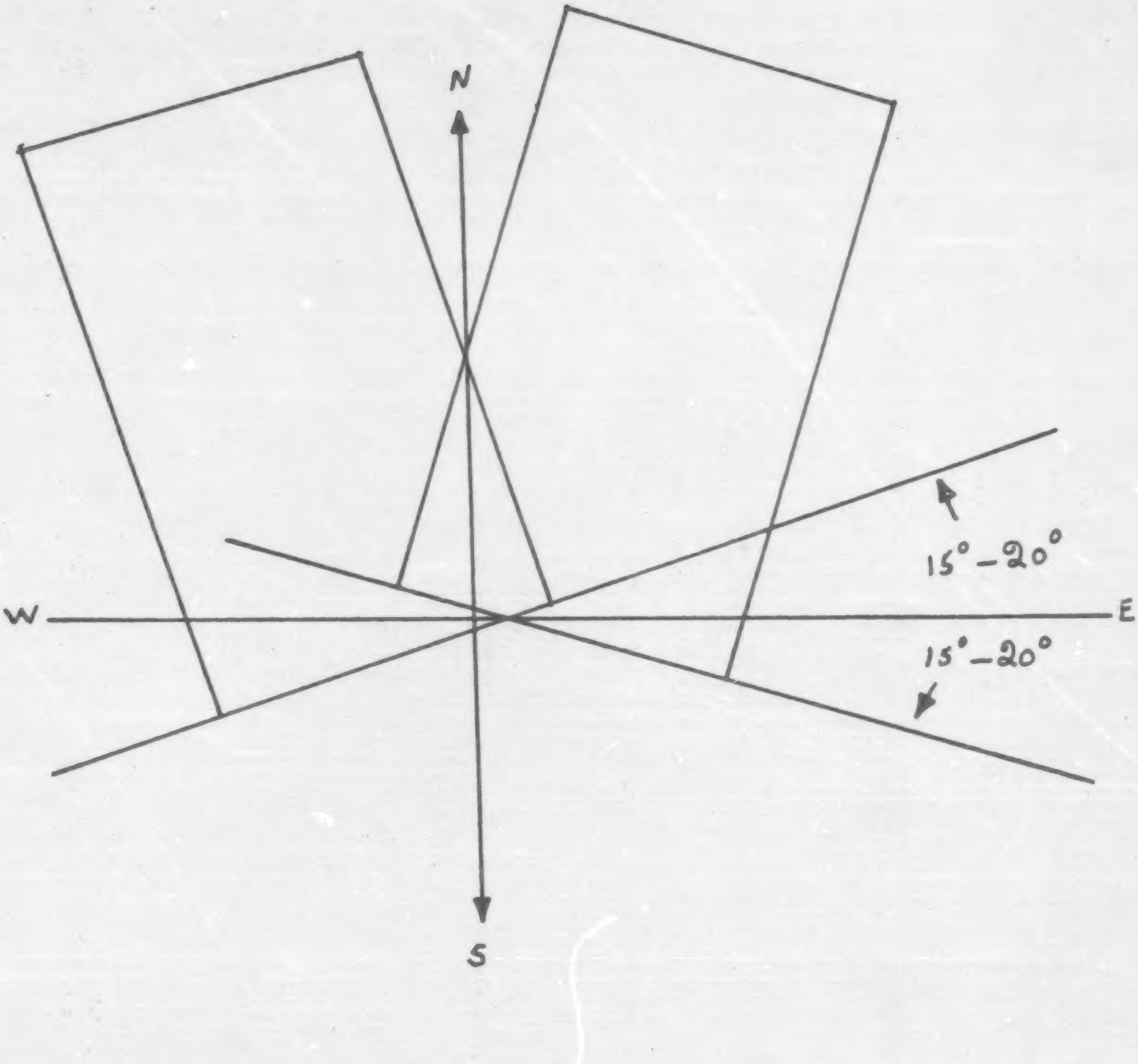

SUN
Sun's Path
Winter Sunset
W
S
N
Winter Sunrise
E
DECEMBER 21

COLLECTOR TILT



Optimum tilt for collector may require roof structure. In the illustration, a 30° roof pitch is increased 20° by a special roof structure for collector panels.

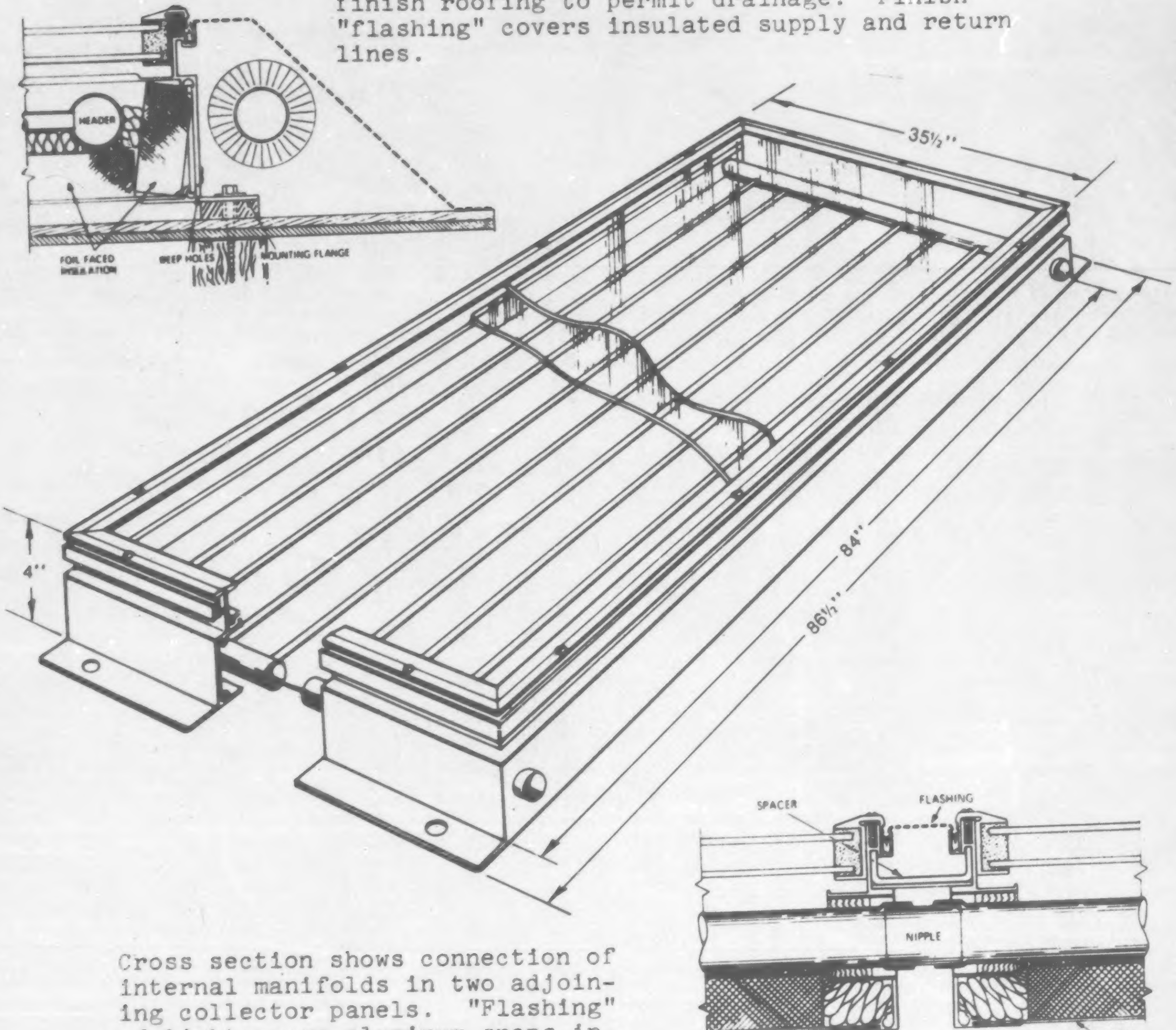
COLLECTOR ORIENTATION



Orientation of collector panels
Permissible orientation of collector from true south

FLAT PLATE COLLECTOR INSTALLATION

Collectors are secured to roof by four lag bolts through a flange on the top and bottom edges of the panel. Bushings of aluminum or non-metallic material elevate panel 3/8 to 5/8 inch above finish roofing to permit drainage. Finish "flashing" covers insulated supply and return lines.



Cross section shows connection of internal manifolds in two adjoining collector panels. "Flashing" of light-gauge aluminum snaps into groove in sides of collectors; provides professional appearance without soldering, carpentry, etc.

Courtesy of
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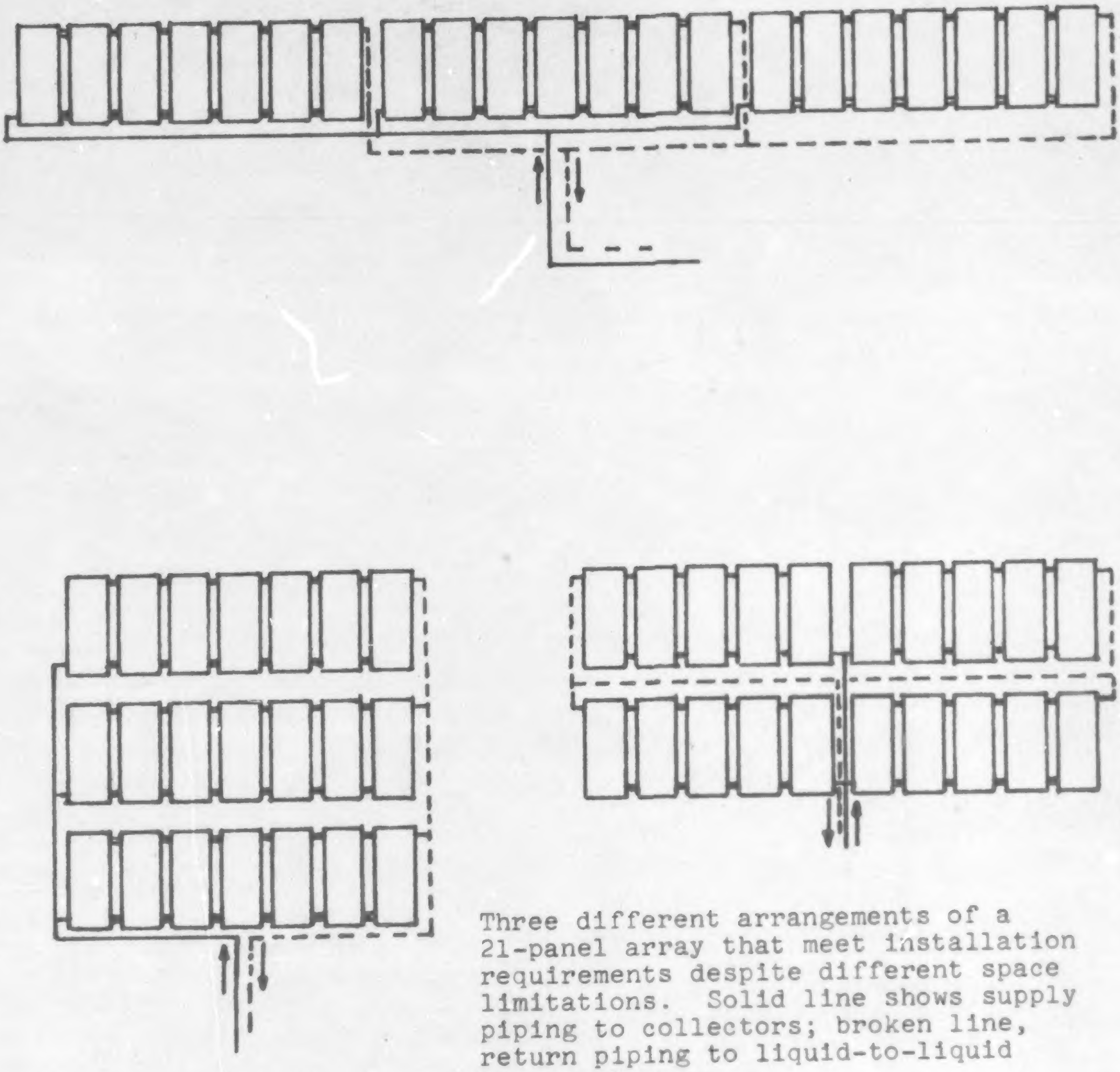
COLLECTOR ARRAYS



Three different arrangements of a 21-panel array that meet installation requirements despite different space limitations. Solid line shows supply piping to collectors; broken line, return piping to liquid-to-liquid heat exchanger.

EQUIVALENT FEET OF TUBING FOR FITTINGS

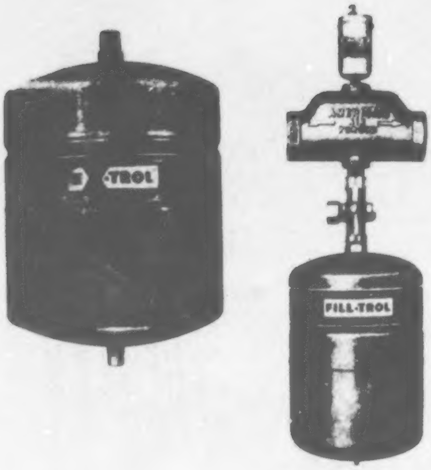
FITTING	TUBING SIZE					
	1/2"	3/4"	1"	1¼"	1½"	2"
90° Elbow	1.5	2.1	2.8	3.7	4.4	5.6
45° Elbow	1.0	1.5	2.0	2.6	3.1	3.9
Gate Valve Open	1.0	1.5	2.0	2.6	3.1	3.9
Globe Valve Open	25.5	35.7	47.6	63.0	75.0	95.0

COLLECTOR LOOP PUMP AND PIPE SIZES

No. of Collectors	Flow Rate GPM	Recommended Circulator Pump	Equivalent Length of Copper Tubing (Ft)									
			20	40	60	80	100	120	140	160	180	200
6	3.3		1/2"	1/2"	5/8"	5/8"	5/8"	5/8"	3/4"	3/4"	3/4"	3/4"
8	4.4		5/8"	5/8"	5/8"	3/4"	3/4"	3/4"	3/4"	1"	1"	1"
10	5.5	Bell & Gossett Series "HV"*	3/4"	3/4"	3/4"	3/4"	1"	1"	1"	1"	1"	1"
12	6.6		3/4"	3/4"	3/4"	1"	1"	1"	1"	1"	1"	1"
14	7.7		1"	1"	1"	1"	1"	1"	1"	1"	1"	1"
16	8.8		1"	1"	1"	1"	1"	1"	1"	1"	1-1/4"	1-1/4"
18	9.9		1"	1"	1"	1"	1"	1"	1"	1-1/4"	1-1/4"	1-1/4"
20	11.0		1"	1"	1"	1"	1"	1"	1-1/4"	1-1/4"	1-1/4"	1-1/4"
22	12.1		1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"
24	13.2		1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"
26	14.3		1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/2"	1-1/2"
28	15.4		1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/2"	1-1/2"	1-1/2"
30	16.5		1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/4"	1-1/2"	1-1/2"	1-1/2"	1-1/2"

*Specify flange size.

EXPANSION TANKS



Courtesy of
Fedders Corporation

SIZING THE EXPANSION TANK

FLUID VOLUME* OF COLLECTOR LOOP COMPONENTS, GALLONS

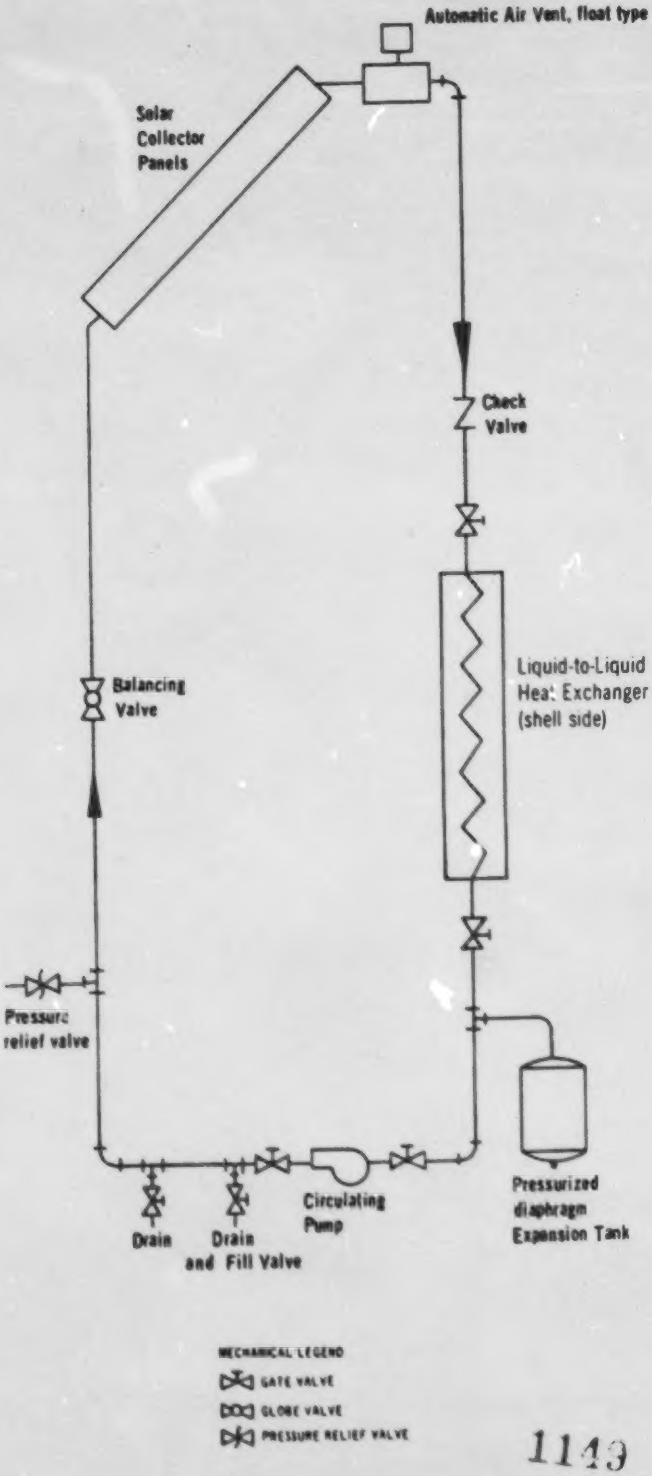
Collectors		Shell Side, Bell & Gossett Heat Exchanger		Collectors		Shell Side, Bell & Gossett Heat Exchanger	
No. of Panels	Fluid Volume Gallons	Model	Gallons	No. of Panels	Fluid Volume Gallons	Model	Gallons
6	2.2	STH315-4	.51	20	7.2	STH520-4	1.35
8	2.9	STH315-2	.51	22	7.9	STH530-2	2.01
10	3.6	STH410-4	.62	24	8.6	STH620-4	1.92
12	4.3	STH415-4	.83	26	9.4	STH620-4	1.92
14	5.0	STH415-4	.83	28	10.1	STH620-4	1.92
16	5.8	STH520-4	1.35	30	10.8	STH620-4	1.92
18	6.5	STH520-4	1.35				

*Add volume of interconnecting tubing.

FLUID VOLUME COPPER TUBING, GALLONS

Size of Tubing	Linear Feet of Copper Tubing							
	50	75	100	150	200	300	350	400
1/2"	.8	1.2	1.6	2.4	3.2	4.8	5.6	6.4
3/4"	1.4	2.1	2.8	4.2	5.6	8.4	9.8	11.2
1"	2.3	3.9	4.6	6.9	9.2	13.8	16.1	18.3
1 1/4"	3.9	5.8	7.8	11.7	15.6	23.4	25.3	31.2
1 1/2"	5.0	7.5	9.9	14.9	19.8	29.7	34.9	39.8

COLLECTOR LOOP COMPONENTS AND FITTINGS

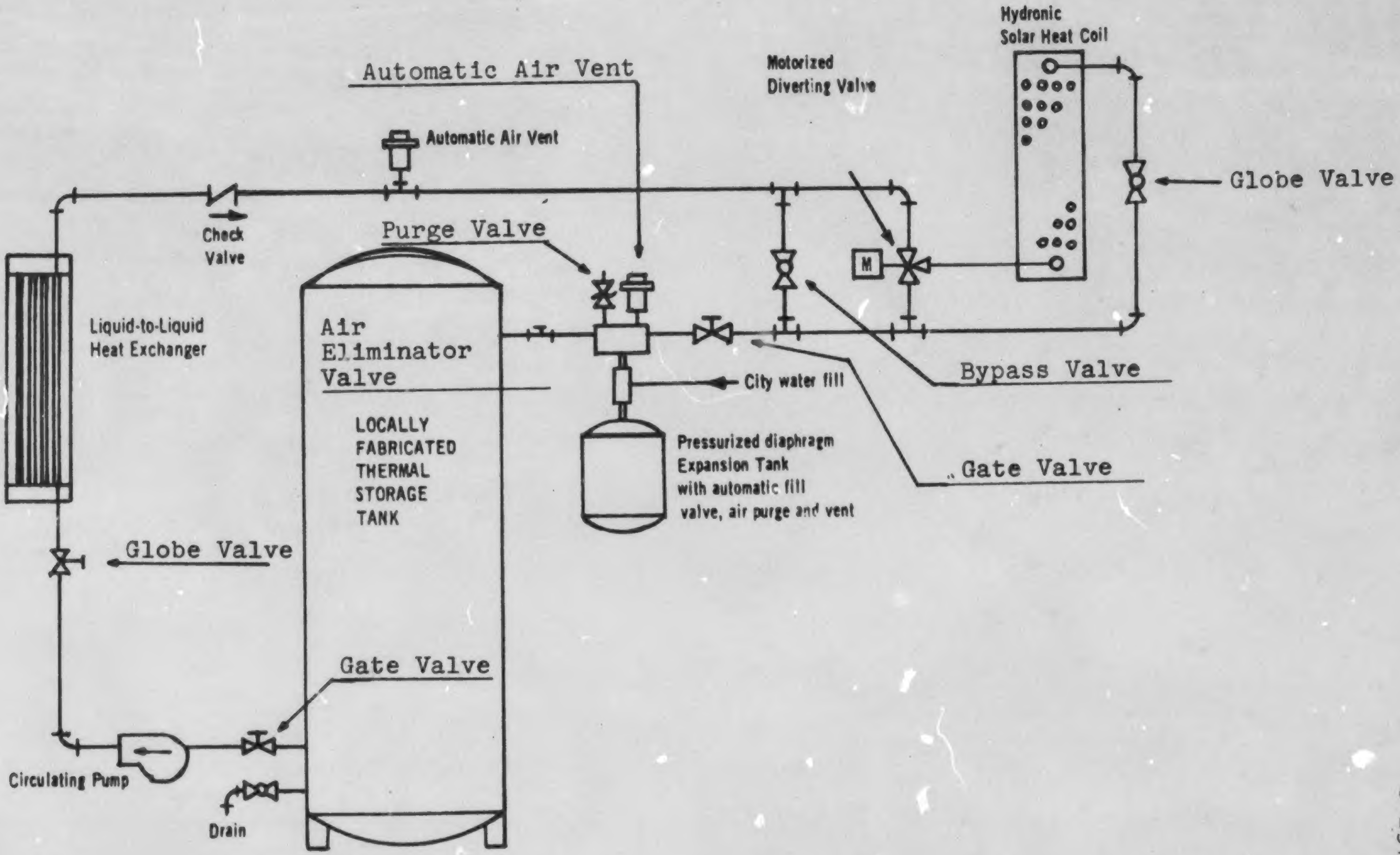


ETHYLENE GLYCOL MIXTURE

ANTI-FREEZE PROTECTION; CONCENTRATION
OF ETHYLENE GLYCOL

% of Ethylene Glycol	Freezing Point (°F)	% of Ethylene Glycol	Freezing Point (°F)
0	32	30	4
5	28	35	-4
10	25	40	-10
15	21	45	-22
20	16	50	-32
25	11		

SOLAR STORAGE/TERMINAL LOOP COMPONENTS



TM 19

1151

S-137-J

1152

BTU OUTPUT OF SAMPLE HEAT PUMPS

MBTU OUTPUT, KW INPUT OF HEAT PUMP MODELS

Outdoor Unit CFM Air Handler	CKH018C 640 CFM CFJ024		CKH024C 860 CFM CFJ024		CKH030B 1100 CFM CFJ036		CKH037B 1100 CFM CFJ036		CKH042B 1600 CFM CKE048	
Outdoor Temp.	BTU	KW	BTU	KW	BTU	KW	BTU	KW	BTU	KW
67°	20.9	2.20	29.0	2.90	38.2	3.60	46.8	5.30	56.7	6.00
62°	20.0	2.20	27.7	2.85	36.5	3.55	44.7	5.20	54.2	5.90
57°	19.1	2.20	26.4	2.80	34.8	3.50	42.7	5.10	51.7	5.80
52°	18.0	2.15	25.0	2.75	32.9	3.45	40.4	5.00	48.9	5.70
47°	17.0	2.10	23.5	2.70	31.0	3.40	38.0	4.90	46.0	5.60
42°	16.0	2.00	22.2	2.65	29.3	3.35	35.9	4.80	43.4	5.50
37°	15.1	2.00	20.8	2.60	27.5	3.30	33.7	4.70	40.8	5.40
33°	14.1	2.00	19.4	2.55	25.6	3.25	31.5	4.65	38.0	5.30
27°	13.1	2.00	18.0	2.50	23.8	3.20	29.2	4.60	35.3	5.20
22°	11.8	1.90	15.5	2.40	21.9	3.10	25.3	4.30	31.6	5.05
17°	10.5	1.80	13.0	2.30	20.0	3.00	21.5	4.00	28.0	4.90
12°	9.8	1.80	12.8	2.25	18.3	2.95	21.0	4.00	27.7	4.85
7°	9.2	1.80	12.7	2.20	16.7	2.90	20.5	4.00	27.5	4.80
2°	8.1	1.80	11.3	2.15	14.8	2.85	18.2	3.95	23.3	4.70
-3°	7.1	1.80	9.8	2.10	12.9	2.80	15.8	3.90	19.1	4.60
-8°	6.0	1.75	8.3	2.10	11.0	2.75	13.5	3.85	16.3	4.50
-13°	5.0	1.70	6.9	2.10	9.1	2.70	11.2	3.80	13.5	4.40
Solar Heating KW Input*		0.6		0.6		0.6		0.8		1.0

*Includes indoor blower plus circulating at all temperatures. Pump KW is averaged for solar energy collection, 9 hours per day maximum.

OUTPUT OF SAMPLE HYDRONIC COILS, MBTU

Model No. CFM	Entering Water Temp. °F	MBTU/H OUTPUT ENTERING AIR 70°F	88°F	90°F	92°F	94°F	96°F
CFX036S2 800 cfm 1 1/2-2 ton heat pumps 6 gpm	100	20.5	8.7	7.4	6.1	4.8	3.5
	110	27.1	15.3	14.0	12.7	11.4	10.1
	120	33.7	21.9	20.6	19.3	18.0	16.7
	130	40.3	28.5	27.2	25.9	24.6	23.3
	140	46.9	35.1	33.8	32.5	31.2	29.9
	150	53.5	41.7	40.4	39.1	37.8	36.4
	160	60.1	48.3	47.0	45.6	44.3	43.0
	170	66.6	54.8	53.5	52.2	50.9	49.6
	180	73.2	61.4	60.1	58.8	57.5	56.2
1200 cfm 2 1/2-3 ton heat pumps 6 gpm	100	26.9	11.4	9.7	8.0	6.3	4.6
	110	35.6	20.1	18.4	16.7	14.9	13.2
	120	44.2	28.8	27.0	25.3	23.6	21.9
	130	52.9	37.4	35.7	34.0	32.3	30.5
	140	61.5	46.0	44.3	42.6	40.9	39.2
	150	70.2	54.7	53.0	51.2	49.5	47.8
	160	78.8	63.3	61.6	59.9	58.1	56.4
	170	87.4	71.9	70.2	68.5	66.8	65.0
	180	96.0	80.5	78.8	77.1	75.4	73.6

PIPING AND PUMPS FOR STORAGE/TERMINAL LOOPS

Recommended tubing sizes for terminal portion of loop:

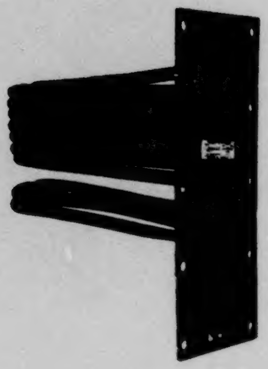
Flow Rate (GPM)	Equivalent Length of Copper Tubing (Ft.)		
	0-30	30-100	100-300
6	3/4"	1"	1 1/4"

Recommended tubing sizes for storage (full flow) portion of loop:

Number of Collectors	Flow Rate (GPM)	Equivalent Length of Copper Tubing (Ft.)				
		20	40	60	80	100
6	6	3/4"	3/4"	1"	1"	1"
8	8	1"	1"	1"	1"	1"
10	10	1"	1"	1"	1 1/4"	1 1/4"
12	12	1 1/4"	1 1/4"	1 1/4"	1 1/4"	1 1/4"
14	14	1 1/4"	1 1/4"	1 1/4"	1 1/2"	1 1/2"
16	16	1 1/4"	1 1/4"	1 1/4"	1 1/2"	1 1/2"
18	18	1 1/4"	1 1/2"	1 1/2"	1 1/2"	1 1/2"
20	20	1 1/4"	1 1/2"	2"	2"	2"
22	22	1 1/2"	1 1/2"	2"	2"	2"
24	24	1 1/2"	2"	2"	2"	2"

IMPORTANT: If selected terminal loop pipe size is larger than selected storage loop pipe size, use terminal loop pipe size for both terminal and storage loops.

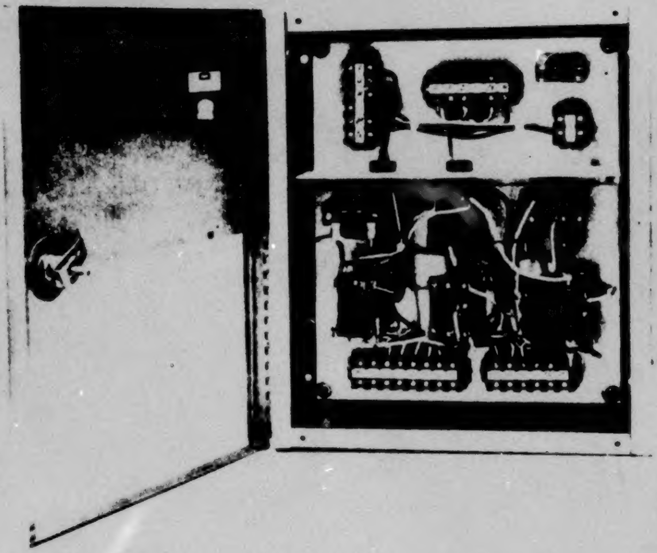
HEAT EXCHANGER



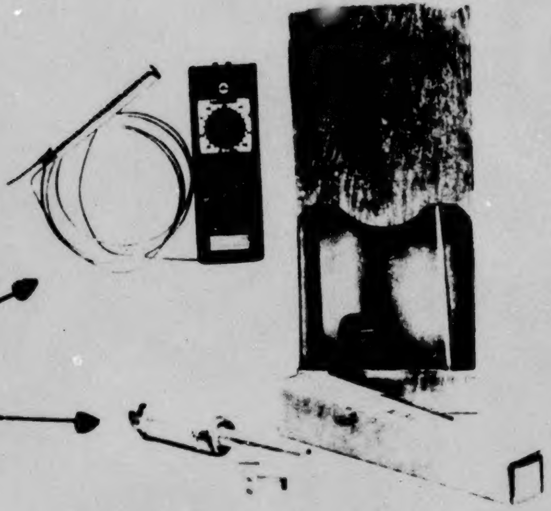
1156

Courtesy of
Fedders Corporation

SYSTEM CONTROL PACKAGE



Main Control Panel

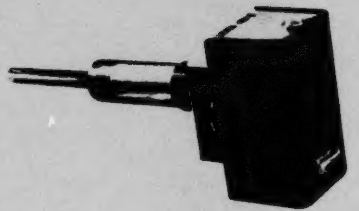


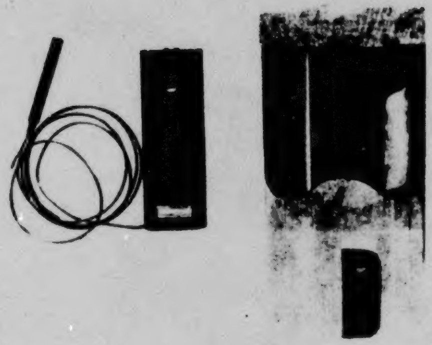
Upper and Lower Operating
Liquid Storage Thermostats
and Thermal Wells for
Sensing Bulbs

Courtesy of
Fedders Corporation

SYSTEM CONTROL PACKAGE
(CONTINUED)

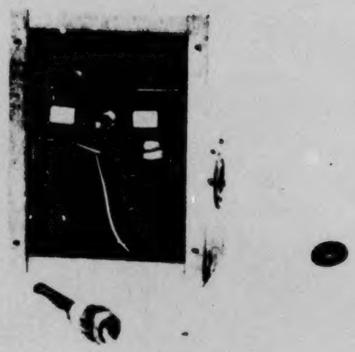
Upper Limit Liquid Storage Thermostat





Outdoor and Balance Point Type Thermostats

Differential Temperature Thermostat



Courtesy of
Fedders Corporation

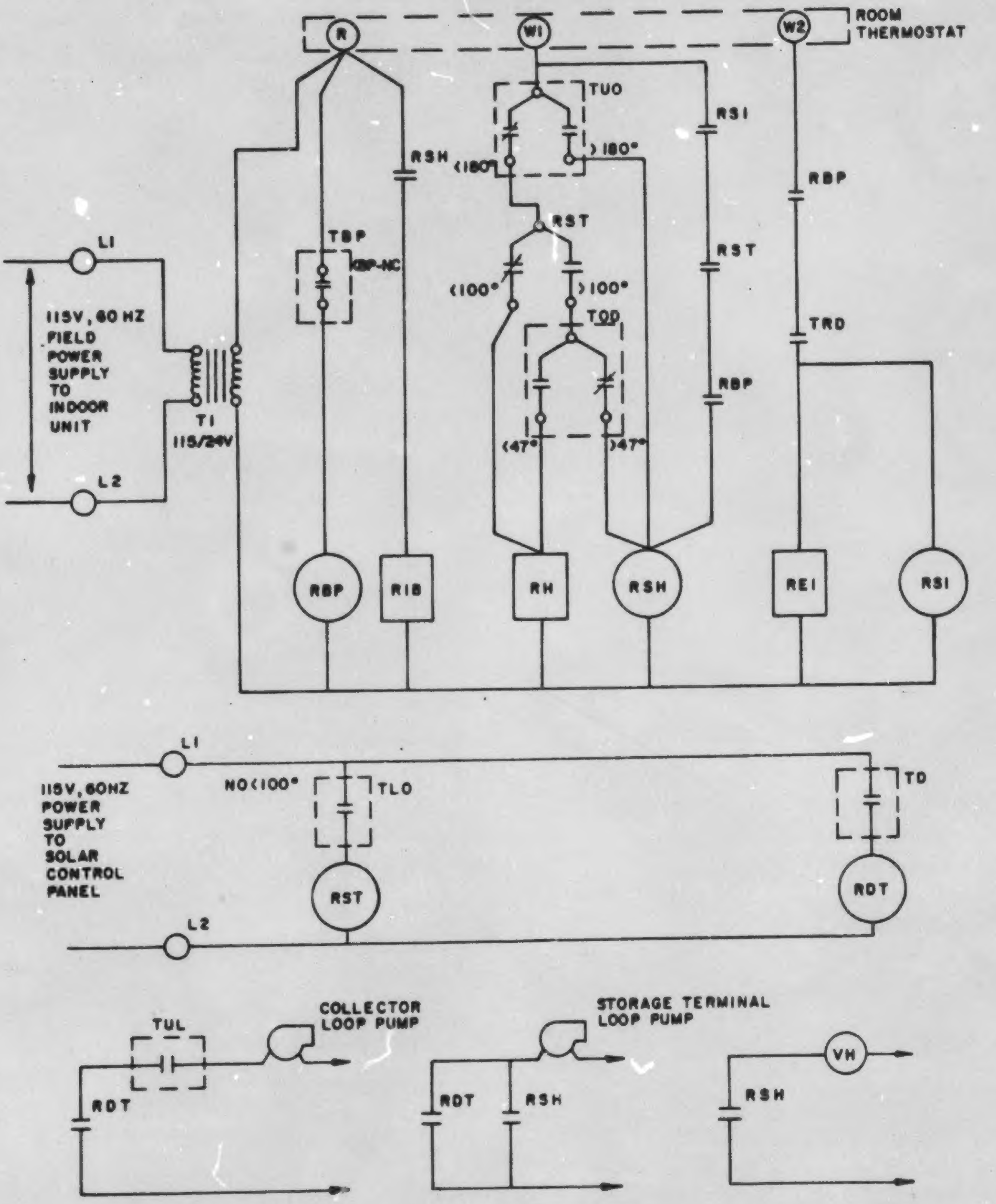
SYSTEM OPERATION ANALYSIS

Diagram No.	Storage Tank Temperature	Outdoor Temperature	1st Stage	2nd Stage	Hydronic Coil	Heat Pump	Electric Heat
1	Above 180°F	Above 47°F	X		Yes	No	No
2	Above 180°F	Above 47°F	X	X	Yes	No	No
3	Above 180°F	47-BP	X		Yes	No	No
4	Above 180°F	47-BP	X	X	Yes	No	No
5	Above 180°F	Below BP	X		Yes	No	No
6*	Above 180°F	Below BP	X	X	Yes	No	Yes
7	180-100°F	Above 47°F	X		Yes	No	No
8	180-100°F	Above 47°F	X	X	Yes	No	No
9	180-100°F	47-BP	X		No	Yes	No
10	180-100°F	47-BP	X	X	No	Yes	No
11**	180-100°F	Below BP	X		Yes	Yes	No
12	180-100°F	Below BP	X	X	No	Yes	Yes
13	Below 100°F	Above 47°F	X		No	Yes	No
14	Below 100°F	Above 47°F	X	X	No	Yes	No
15	Below 100°F	47-BP	X		No	Yes	No
16	Below 100°F	47-BP	X	X	No	Yes	No
17	Below 100°F	Below BP	X		No	Yes	No
18	Below 100°F	Below BP	X	X	No	Yes	Yes

TM 26

*Electric Heat and Hydronic Heat "On" Together.
**On Defrost Electric Heat and Hydronic Heat "On" Together

WIRING DIAGRAMS - SOLAR SYSTEM

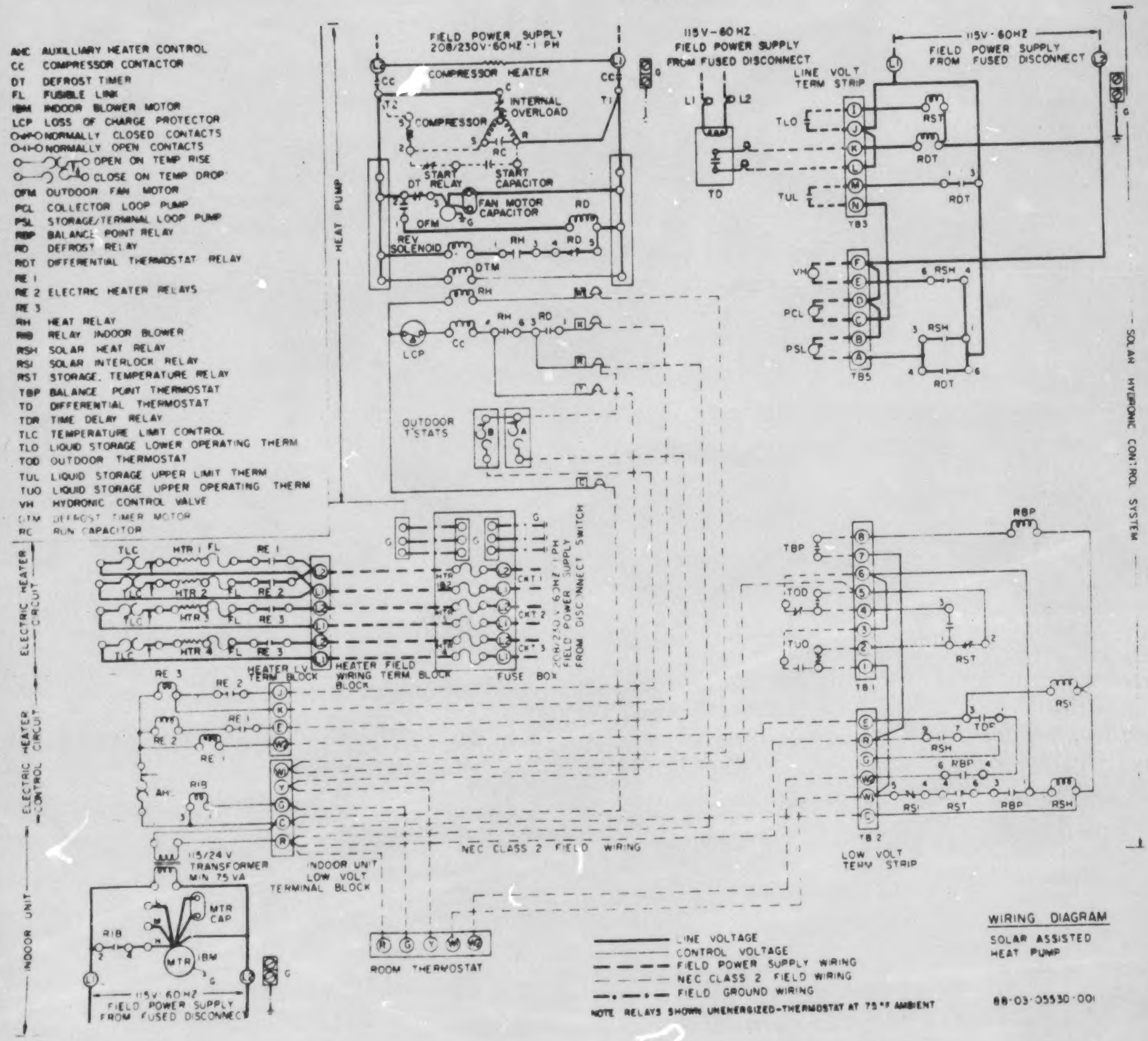


PCL : COLLECTOR LOOP PUMP
PSL.. STORAGE/TERMINAL LOOP PUMP
RBP . BALANCE POINT RELAY
RD... DEFROST RELAY
RDT . DIFFERENTIAL THERMOSTAT RELAY
RE1 . ELECTRIC HEATER RELAY

RH... HEAT RELAY
RIB.. RELAY INDOOR BLOWER
RSH . SOLAR HEAT RELAY
RSI . SOLAR INTERLOCK RELAY
RST . STORAGE. TEMPERATURE RELAY
TBP . BALANCE POINT THERMOSTAT
.TD... DIFFERENTIAL THERMOSTAT
TDR . TIME DELAY RELAY

TLO . LIQUID STORAGE LOWER OPERATING THERM
TOD . OUTDOOR THERMOSTAT
TUL . LIQUID STORAGE UPPER LIMIT THERM
TUO . LIQUID STORAGE UPPER OPERATING THERM
VH... HYDRONIC CONTROL VALVE

WIRING DIAGRAM - SOLAR ASSISTED HEAT PUMP

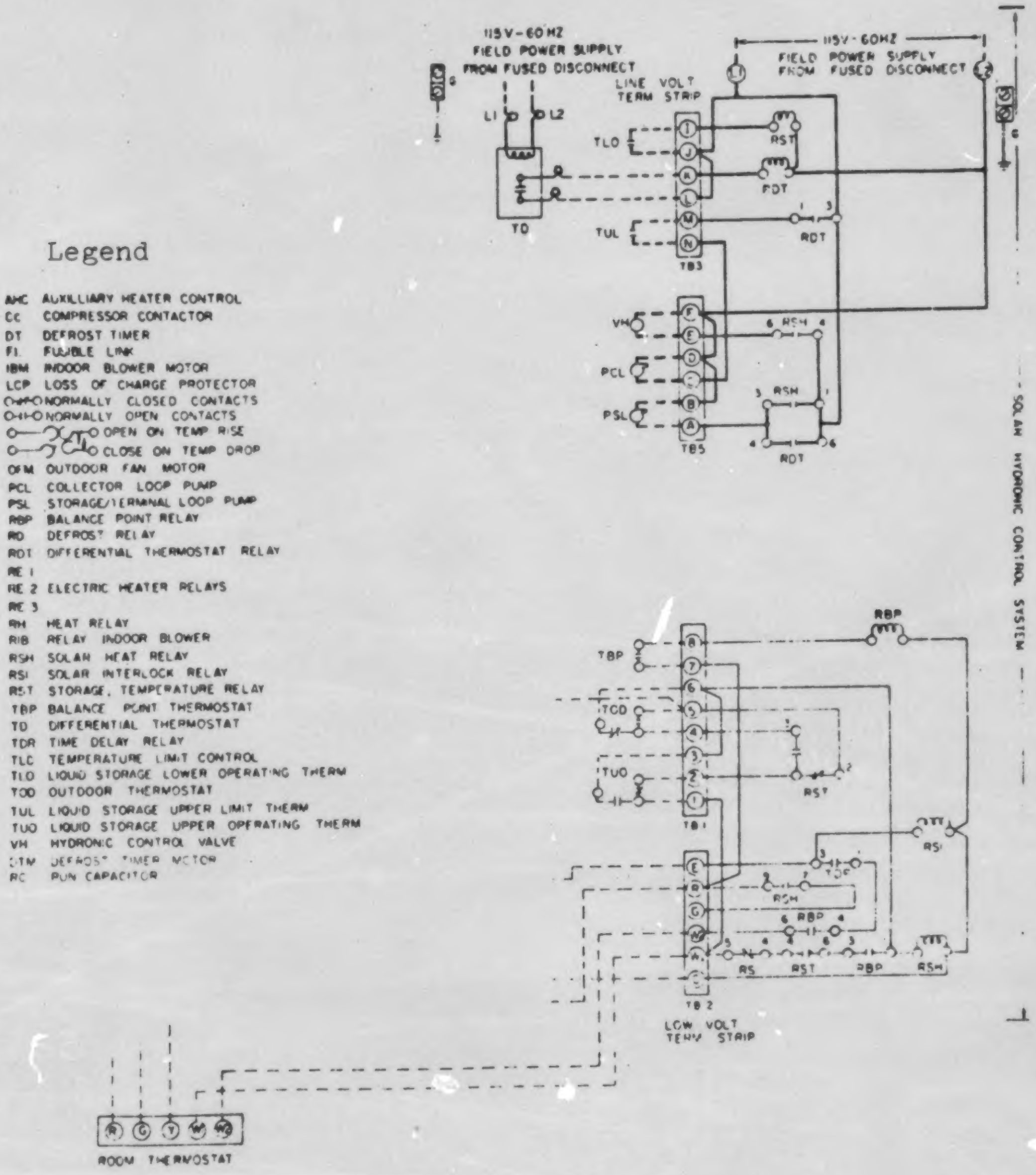

AHC AUXILLIARY HEATER CONTROL
CC COMPRESSOR CONTACTOR
DT DEFROST TIMER
FL FUSIBLE LINK
IBM INDOOR BLOWER MOTOR
LCP LOSS OF CHARGE PROTECTOR
NORMALLY CLOSED CONTACTS
NORMALLY OPEN CONTACTS
OPEN ON TEMP RISE
CLOSE ON TEMP DROP
OFM OUTDOOR FAN MOTOR
PCL COLLECTOR LOOP PUMP
PSL STORAGE/TERMINAL LOOP PUMP
RBP BALANCE POINT RELAY
RD DEFROST RELAY
RDT DIFFERENTIAL THERMOSTAT RELAY
RE 1
RE 2 ELECTRIC HEATER RELAYS
RE 3
RH HEAT RELAY
RIB RELAY INDOOR BLOWER
RSH SOLAR HEAT RELAY
RSI SOLAR INTERLOCK RELAY
RST STORAGE. TEMPERATURE RELAY
TBP BALANCE POINT THERMOSTAT
TD DIFFERENTIAL THERMOSTAT
TDR TIME DELAY RELAY
TLC TEMPERATURE LIMIT CONTROL
TLO LIQUID STORAGE LOWER OPERATING THERM
TOD OUTDOOR THERMOSTAT
TUL LIQUID STORAGE UPPER LIMIT THERM
TUO LIQUID STORAGE UPPER OPERATING THERM
VH HYDRONIC CONTROL VALVE
DTM DEFROST TIMER MOTOR
RC RUN CAPACITOR
FIELD POWER SUPPLY 208/230V-60HZ-1 PH
COMPRESSOR HEATER
INTERNAL OVERLOAD
COMPRESSOR
START RELAY
START CAPACITOR
FAN MOTOR CAPACITOR
REV SOLENOID
HEAT PUMP
LCP
OUTDOOR T'STATS
115V-60HZ FIELD POWER SUPPLY FROM FUSED DISCONNECT
TD
LINE VOLT TERM STRIP
TB3
TB5
115V-60HZ FIELD POWER SUPPLY FROM FUSED DISCONNECT
SOLAR HYDRONIC CONTROL SYSTEM
ELECTRIC HEATER CIRCUIT
HEATER LV TERM BLOCK
HEATER FIELD WIRING TERM BLOCK
FUSE BOX
208/230V 60HZ 1 PH FIELD POWER SUPPLY FROM DISCONNECT SWITCH
ELECTRIC HEATER CONTROL CIRCUIT
115/24 V TRANSFORMER MIN 75 VA
INDOOR UNIT LOW VOLT TERMINAL BLOCK
NEC CLASS 2 FIELD WIRING
INDOOR UNIT
MTR CAP
115V 60HZ FIELD POWER SUPPLY FROM FUSED DISCONNECT
ROOM THERMOSTAT
TB 1
TB 2
LOW VOLT TERM STRIP
LINE VOLTAGE
CONTROL VOLTAGE
FIELD POWER SUPPLY WIRING
NEC CLASS 2 FIELD WIRING
FIELD GROUND WIRING
NOTE RELAYS SHOWN UNENERGIZED-THERMOSTAT AT 75°F AMBIENT
WIRING DIAGRAM
SOLAR ASSISTED HEAT PUMP
88-03-05530-001

Courtesy of
Fedders Corporation

SOLAR ASSISTED HEAT PUMP SYSTEMS
UNIT II

ASSIGNMENT SHEET #1--ISOLATE SOLAR HEAT CIRCUITS ONLY IN A WIRING DIAGRAM

Directions: Use a lead pencil to circle each relay, motor and set of contacts used to energize the solar heat circuits in the diagram below.



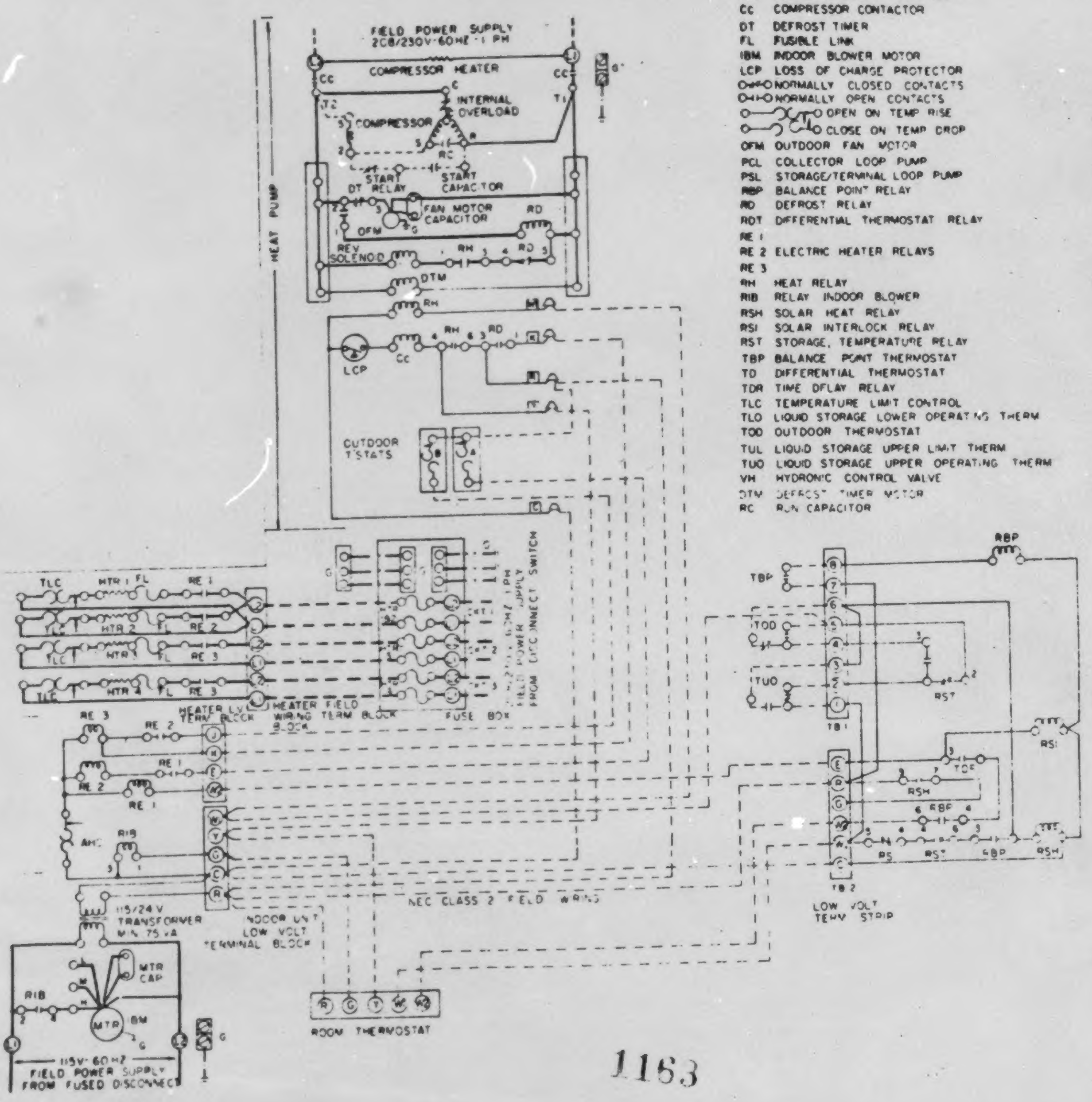
Legend

AHC	AUXILLIARY HEATER CONTROL
CC	COMPRESSOR CONTACTOR
DT	DEFROST TIMER
FL	FUSIBLE LINK
IBM	INDOOR BLOWER MOTOR
LCP	LOSS OF CHARGE PROTECTOR
○┤/├○	NORMALLY CLOSED CONTACTS
○┤├○	NORMALLY OPEN CONTACTS
○—⌒○	OPEN ON TEMP RISE
○—⌒○	CLOSE ON TEMP DROP
OFM	OUTDOOR FAN MOTOR
PCL	COLLECTOR LOOP PUMP
PSL	STORAGE/TERMINAL LOOP PUMP
RBP	BALANCE POINT RELAY
RD	DEFROST RELAY
RDT	DIFFERENTIAL THERMOSTAT RELAY
RE 1	
RE 2	ELECTRIC HEATER RELAYS
RE 3	
RH	HEAT RELAY
RIB	RELAY INDOOR BLOWER
RSH	SOLAR HEAT RELAY
RSI	SOLAR INTERLOCK RELAY
RST	STORAGE, TEMPERATURE RELAY
TBP	BALANCE POINT THERMOSTAT
TD	DIFFERENTIAL THERMOSTAT
TDR	TIME DELAY RELAY
TLC	TEMPERATURE LIMIT CONTROL
TLO	LIQUID STORAGE LOWER OPERATING THERM
TOD	OUTDOOR THERMOSTAT
TUL	LIQUID STORAGE UPPER LIMIT THERM
TUO	LIQUID STORAGE UPPER OPERATING THERM
VH	HYDRONIC CONTROL VALVE
DTM	DEFROST TIMER MOTOR
RC	RUN CAPACITOR

SOLAR ASSISTED HEAT PUMP SYSTEMS
UNIT II

ASSIGNMENT SHEET #2--ISOLATE HEAT PUMP CIRCUITS ONLY IN A WIRING DIAGRAM

Directions: Using a lead pencil circle each relay coil and set of contacts involved in providing power to the heat pump indoor and outdoor units in the second heat phase in the diagram below.



Legend

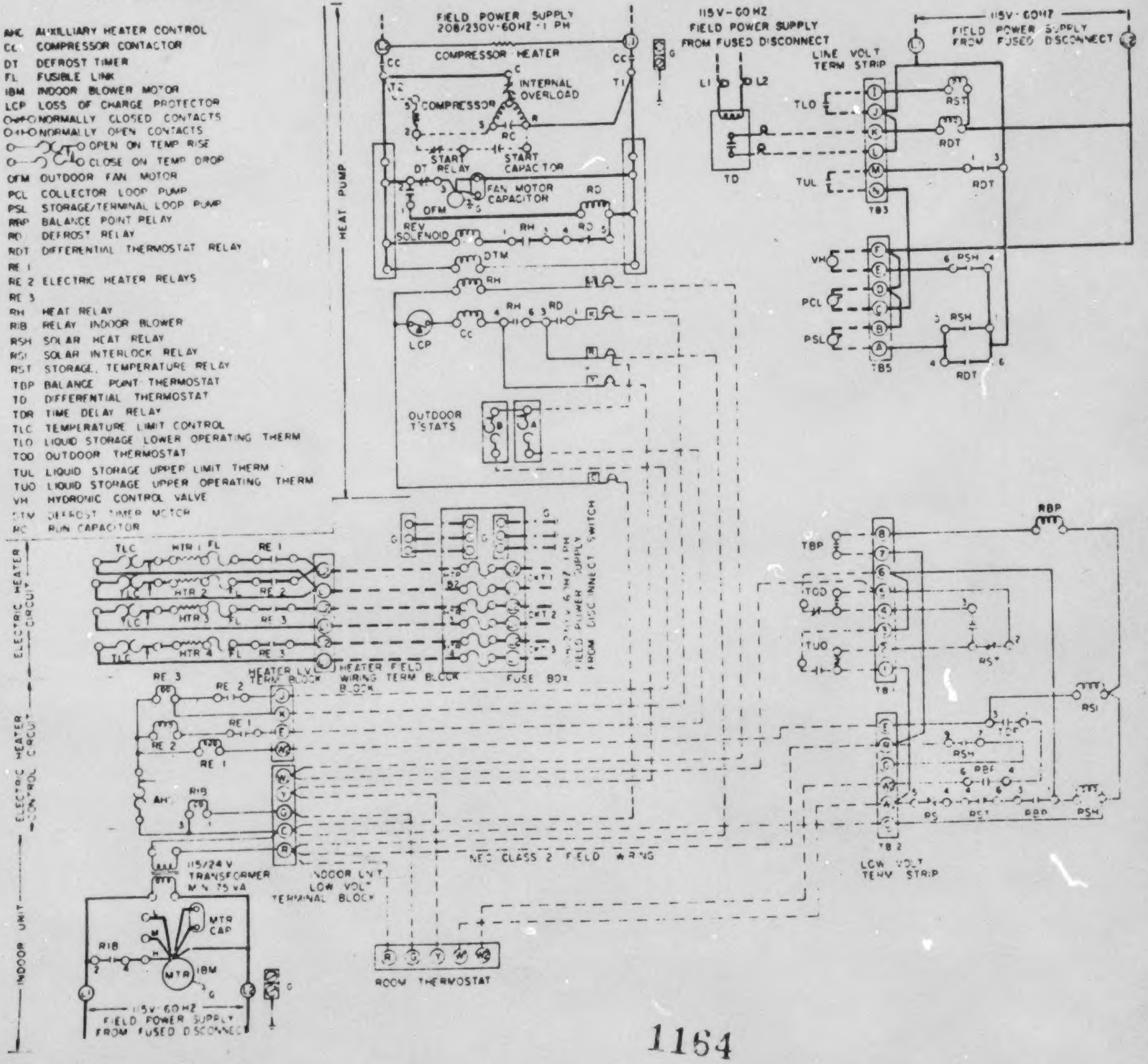
AHC	AUXILLIARY HEATER CONTROL
CC	COMPRESSOR CONTACTOR
DT	DEFROST TIMER
FL	FUSIBLE LINK
IBM	INDOOR BLOWER MOTOR
LCP	LOSS OF CHARGE PROTECTOR
○╫○	NORMALLY CLOSED CONTACTS
○┤├○	NORMALLY OPEN CONTACTS
○—⌒⌒—○	OPEN ON TEMP RISE
○—⌒ ⌒—○	CLOSE ON TEMP DROP
OFM	OUTDOOR FAN MOTOR
PCL	COLLECTOR LOOP PUMP
PSL	STORAGE/TERMINAL LOOP PUMP
RBP	BALANCE POINT RELAY
RD	DEFROST RELAY
RDT	DIFFERENTIAL THERMOSTAT RELAY
RE 1	
RE 2	ELECTRIC HEATER RELAYS
RE 3	
RH	HEAT RELAY
RIB	RELAY INDOOR BLOWER
RSH	SOLAR HEAT RELAY
RSI	SOLAR INTERLOCK RELAY
RST	STORAGE, TEMPERATURE RELAY
TBP	BALANCE POINT THERMOSTAT
TD	DIFFERENTIAL THERMOSTAT
TDR	TIME DELAY RELAY
TLC	TEMPERATURE LIMIT CONTROL
TLO	LIQUID STORAGE LOWER OPERATING THERM
TOO	OUTDOOR THERMOSTAT
TUL	LIQUID STORAGE UPPER LIMIT THERM
TUO	LIQUID STORAGE UPPER OPERATING THERM
VH	HYDRONIC CONTROL VALVE
DTM	DEFROST TIMER MOTOR
RC	RUN CAPACITOR

SOLAR ASSISTED HEAT PUMP SYSTEMS
UNIT II

ASSIGNMENT SHEET #3--ISOLATE RELAYS, CONTACTS AND MOTORS FOR HEAT PUMP OPERATION WITH SOLAR SUBSYSTEM SUPPORT

Directions: Using a lead pencil circle each relay, motor and contacts used to energize the heat pump and solar subsystem in the diagram below.

Legend



AHC	AUXILLIARY HEATER CONTROL
CC	COMPRESSOR CONTACTOR
DT	DEFROST TIMER
FL	FUSIBLE LINK
IBM	INDOOR BLOWER MOTOR
LCP	LOSS OF CHARGE PROTECTOR
○-|/|-○	NORMALLY CLOSED CONTACTS
○-| |-○	NORMALLY OPEN CONTACTS
○— ⌒ ○	OPEN ON TEMP RISE
○— ⌒ ○	CLOSE ON TEMP DROP
OFM	OUTDOOR FAN MOTOR
PCL	COLLECTOR LOOP PUMP
PSL	STORAGE/TERMINAL LOOP PUMP
RBP	BALANCE POINT RELAY
RD	DEFROST RELAY
RDT	DIFFERENTIAL THERMOSTAT RELAY
RE 1 RE 2 RE 3	ELECTRIC HEATER RELAYS
RH	HEAT RELAY
RIB	RELAY INDOOR BLOWER
RSH	SOLAR HEAT RELAY
RSI	SOLAR INTERLOCK RELAY
RST	STORAGE TEMPERATURE RELAY
TBP	BALANCE POINT THERMOSTAT
TD	DIFFERENTIAL THERMOSTAT
TDR	TIME DELAY RELAY
TLC	TEMPERATURE LIMIT CONTROL
TLO	LIQUID STORAGE LOWER OPERATING THERM
TOO	OUTDOOR THERMOSTAT
TUL	LIQUID STORAGE UPPER LIMIT THERM
TUO	LIQUID STORAGE UPPER OPERATING THERM
VH	HYDRONIC CONTROL VALVE
DTM	DEFROST TIMER MOTOR
RC	RUN CAPACITOR

SOLAR ASSISTED HEAT PUMP SYSTEMS
UNIT II

ASSIGNMENT SHEET #4--ISOLATE HEAT PUMP, FIRST AND SECOND STAGE RESISTANCE HEATER CIRCUITS ONLY, IN A WIRING DIAGRAM

Directions: Using a lead pencil circle each relay, motor and contacts used to energize the heat pump system and resistance heaters 1 and 2 in the diagram below.

Legend

AHC	AUXILLIARY HEATER CONTROL
Cc	COMPRESSOR CONTACTOR
DT	DEFROST TIMER
FL	FUSIBLE LINK
IBM	INDOOR BLOWER MOTOR
LCP	LOSS OF CHARGE PROTECTOR
O-|/|-O	NORMALLY CLOSED CONTACTS
O-| |-O	NORMALLY OPEN CONTACTS
	OPEN ON TEMP RISE
	CLOSE ON TEMP DROP
OFM	OUTDOOR FAN MOTOR
PCL	COLLECTOR LOOP PUMP
PSL	STORAGE/TERMINAL LOOP PUMP
RBP	BALANCE POINT RELAY
RD	DEFROST RELAY
RDT	DIFFERENTIAL THERMOSTAT RELAY
RE 1 RE 2 RE 3	ELECTRIC HEATER RELAYS
RH	HEAT RELAY
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TBP	BALANCE POINT THERMOSTAT
TD	DIFFERENTIAL THERMOSTAT
TDR	TIME DELAY RELAY
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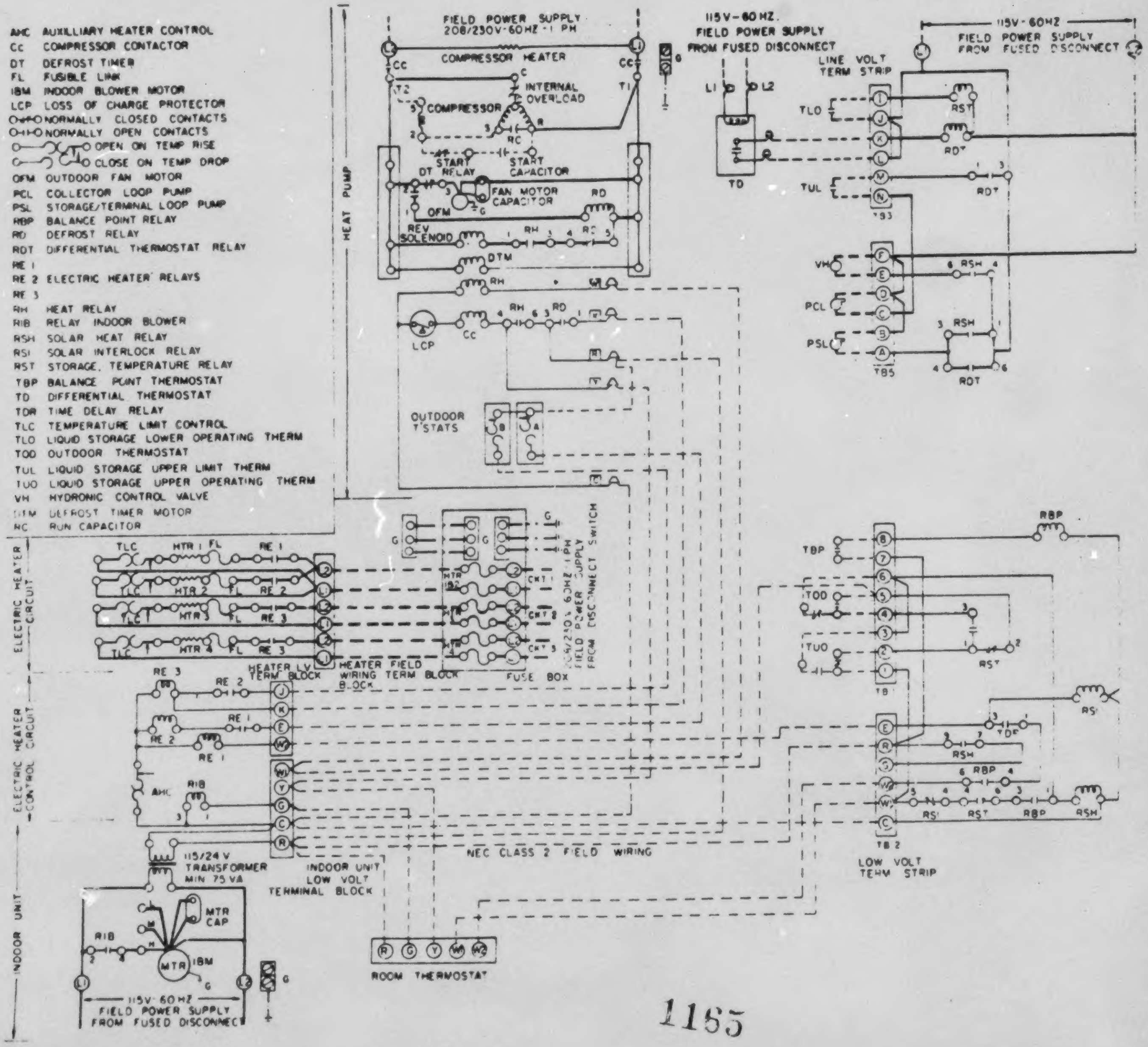
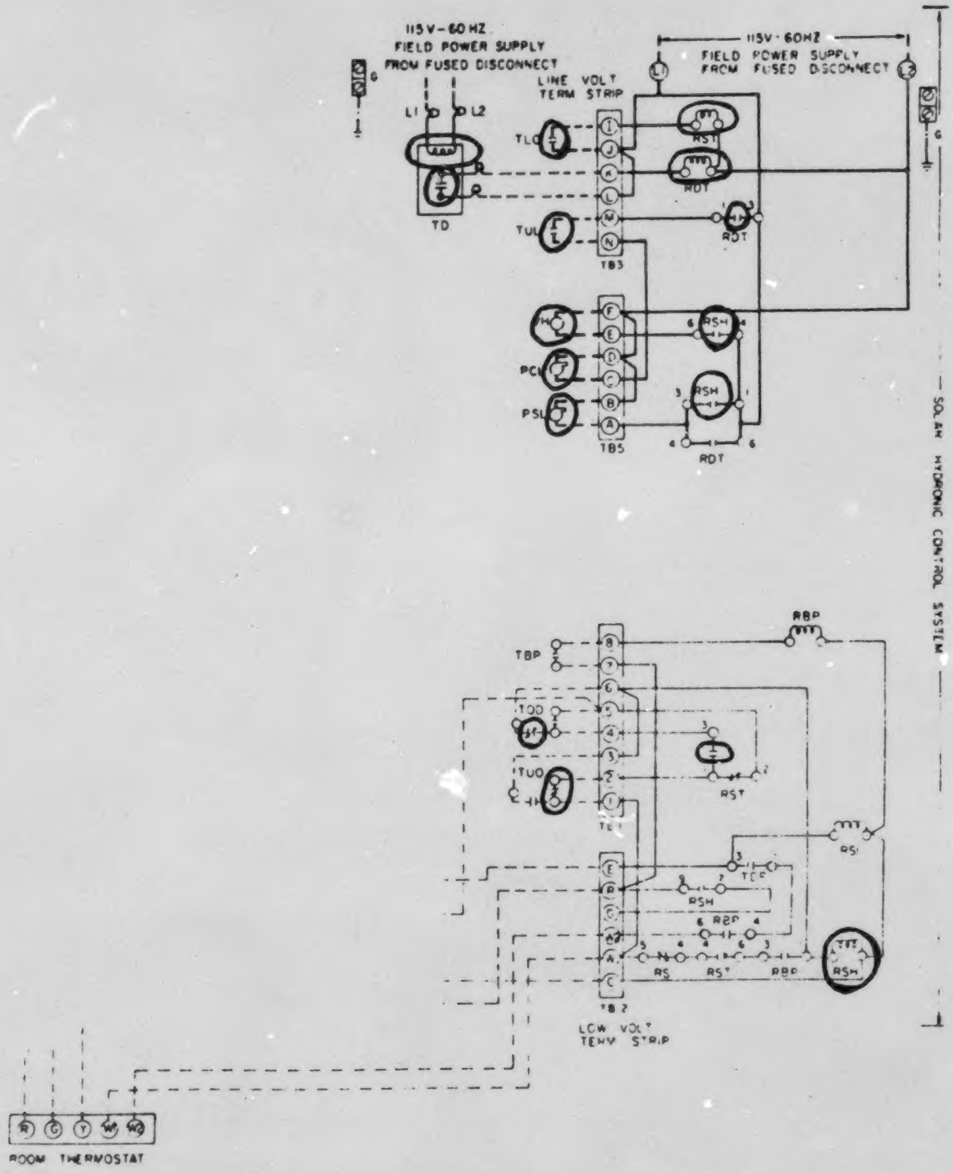
TLO	LIQUID STORAGE LOWER OPERATING THERM
TOO	OUTDOOR THERMOSTAT
TUL	LIQUID STORAGE UPPER LIMIT THERM
TUO	LIQUID STORAGE UPPER OPERATING THERM
VH	HYDRONIC CONTROL VALVE
DTM	DEFROST TIMER MOTOR
RC	RUN CAPACITOR



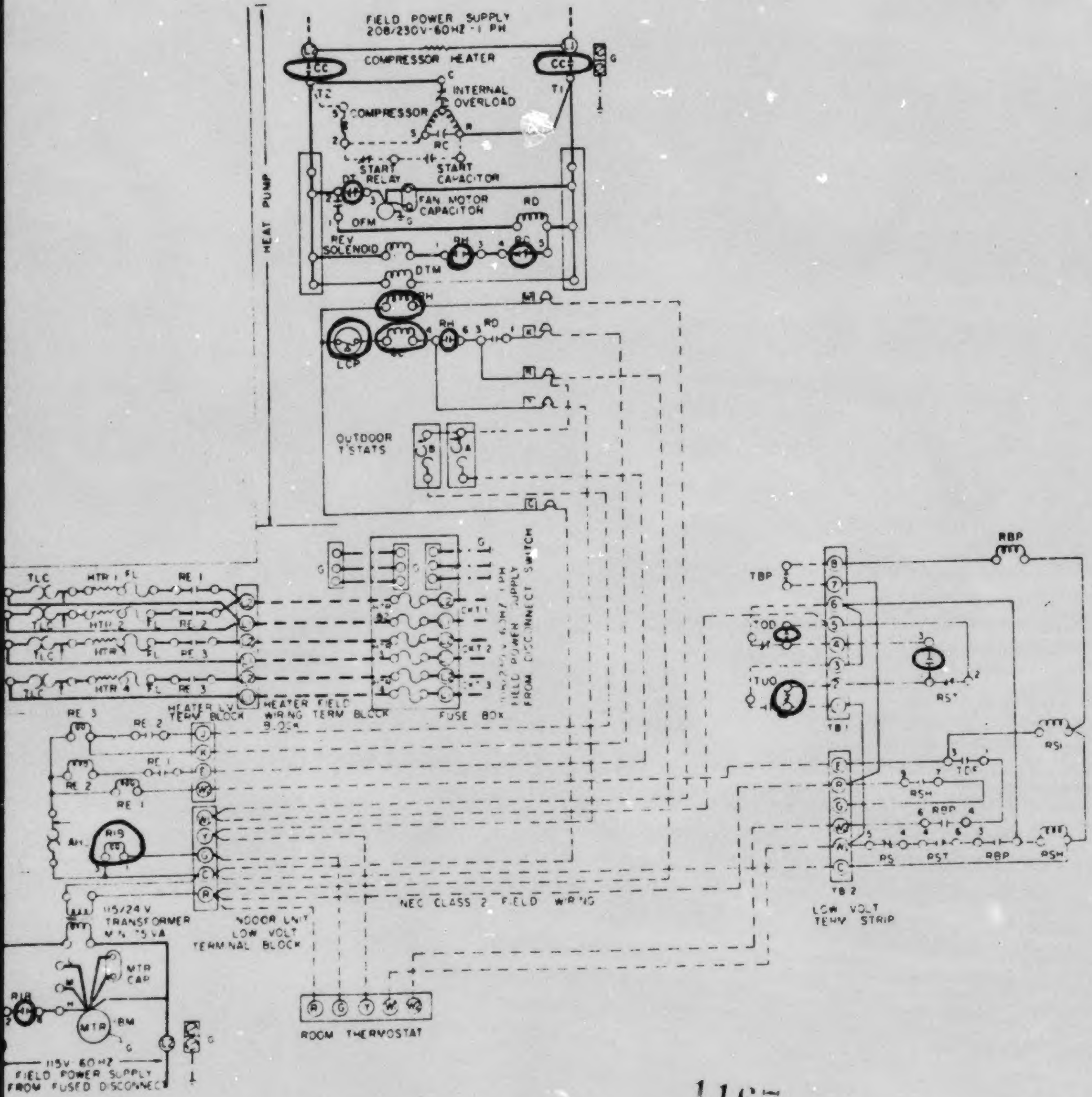
SOLAR ASSISTED HEAT PUMP SYSTEMS
UNIT II

ANSWERS TO ASSIGNMENT SHEETS

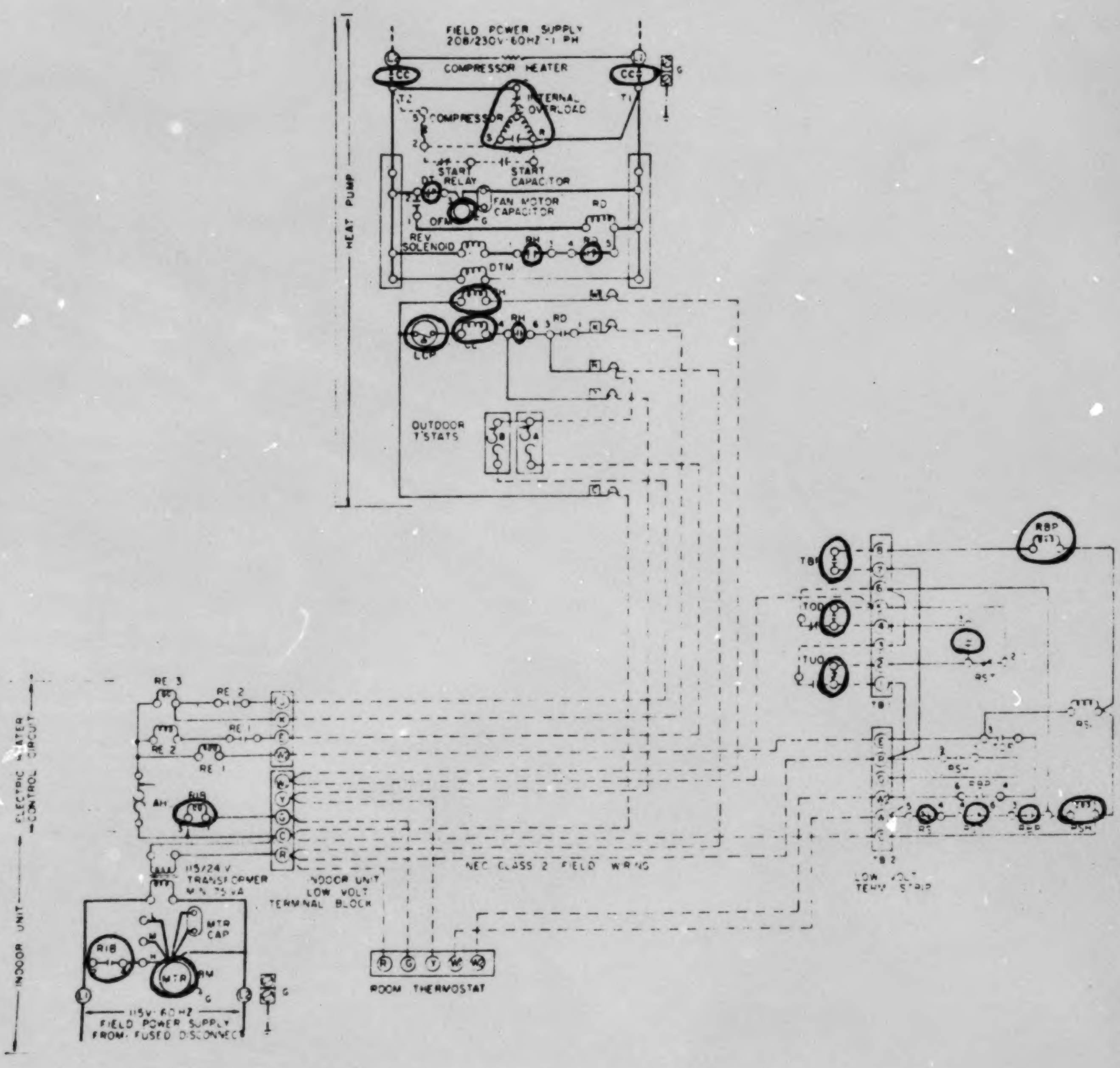
Assignment Sheet #1



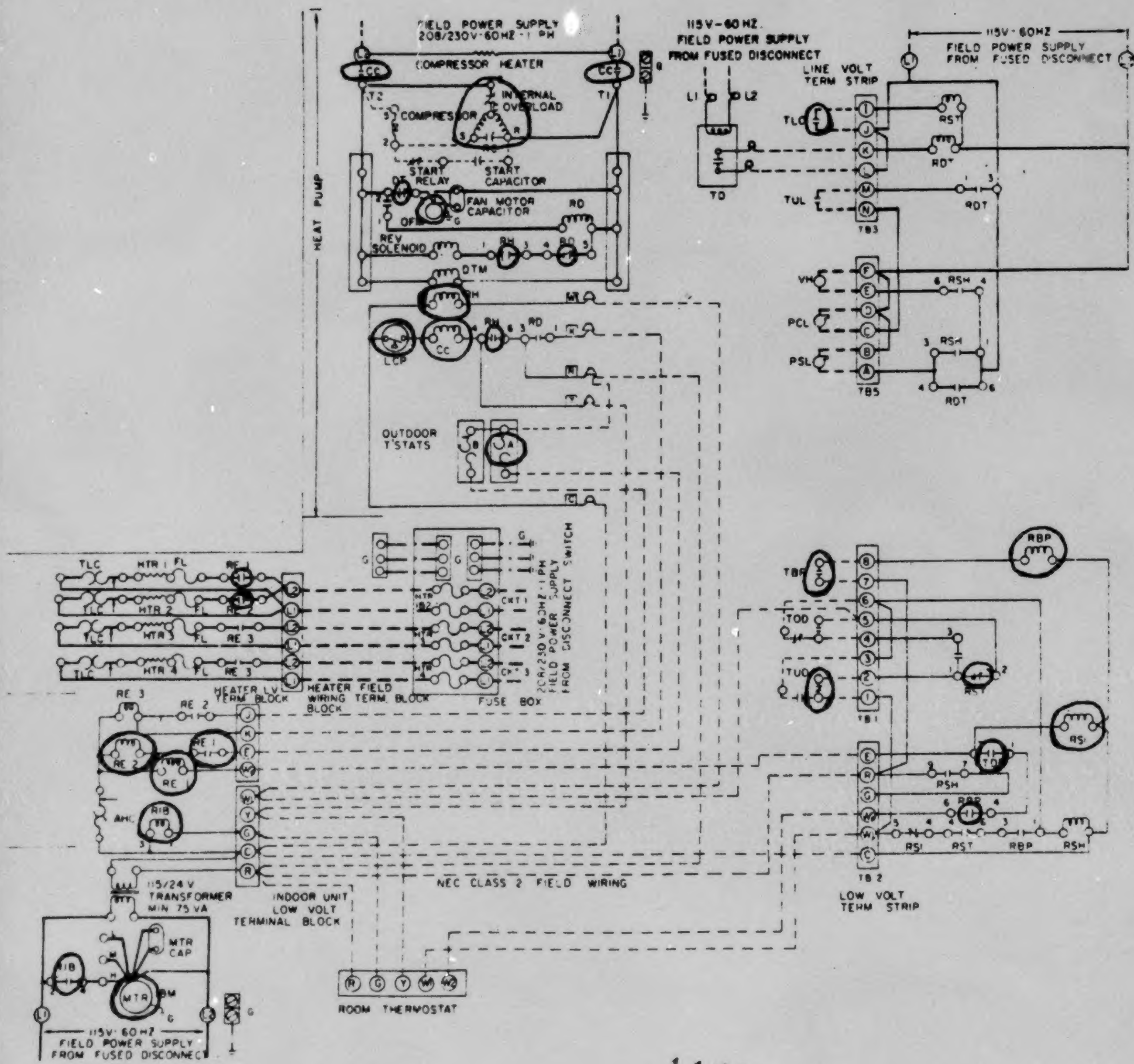
Assignment Sheet #2



Assignment Sheet #3



Assignment Sheet #4



SOLAR ASSISTED HEAT PUMP SYSTEMS
UNIT II.

JOB SHEET #1--INSTALL A COLLECTOR LOOP FOR A SOLAR ASSISTED HEAT PUMP

I. Tools, materials and components

   A. Basic hand tools

   B. Torch outfit

   C. Silver bearing solder

   D. Flux

   E. Collector plates

   F. Installation hardware

   G. Liquid heat exchanger

   H. Expansion tank

   I. Circulator pump

   J. Differential thermostat and sensors

   K. Valves, pipe fittings, pipe insulation, supports, etc.

   L. Required miscellaneous items provided by the instructor

   M. Installation instructions

   N. Electrical supplies for wiring, if needed

   O. Heat transfer fluid

   (NOTE: Your instructor may select water as the transfer fluid for training projects.)

II. Procedures

   A. Assemble required tools, materials and components at appointed site

   B. Study the installation instructions carefully

C. Install the collectors according to instructions

D. Install the circulator pump

E. Install the expansion tank

F. Install the required pipe, fittings, valves, insulation and supports

G. Install the collector plate sensor

H. Install the differential thermostat

I. Install electrical wiring for pump and differential thermostat

(NOTE: Field installations may require that all piping and wiring be done by or under the supervision of a licensed electrician and plumber.)

J. Have your instructor evaluate the installation

Date______________ By___________________________

K. Check the system for leaks following procedures outlined by the manufacturer or your instructor.

L. Have your instructor evaluate testing procedures and results

Date______________ By___________________________

M. Return all unused materials and supplies to storage

N. Return all tools and equipment to their assigned areas

O. Clean up your installation site

SOLAR ASSISTED HEAT PUMP SYSTEMS
UNIT II

JOB SHEET #2--INSTALL A SPLIT-HEAT PUMP SYSTEM

I. Tools, materials and components

- A. Basic hand tools
- B. Torch outfit
- C. Silver bearing solder
- D. Soldering flux

  (NOTE: Your instructor may specify a brazing alloy to meet manufacturer's installation requirements.)

- E. Outdoor unit
- F. Indoor unit
- G. Resistance heater unit
- H. Room thermostat
- I. Pipe, fittings, pipe insulation, supports, etc.

  (NOTE: Only refrigeration grade copper pipe that is received sealed should be used for the refrigerant piping.)

- J. Wiring supplies and thermostat cable
- K. Air handler
- L. Torpedo level
- M. Supply of duct board
- N. Tools for cutting duct board
- O. Duct tape
- P. Outdoor thermostats

II. Procedures

- A. Assemble required tools, materials and components

B. Study all installation instructions carefully

C. Locate the outdoor unit and level

D. Locate the air handler and level

E. Install the indoor unit coil

F. Cut the duct board to form a plenum and duct as specified by your instructor; tape as needed

G. Install refrigerant piping between the indoor and outdoor units

(NOTE: Pipe insulation should be installed on the larger line that serves as the suction line in the cooling cycle.)

H. Install pipe supports as instructed

I. Install the room thermostat and low voltage wiring

J. Have your instructor evaluate the installation

Date______________ By____________________________

K. Install the resistance heater unit

L. Install the power supply for the indoor air handler

M. Install the power supply for the resistance heater unit

N. Install the power supply for the outdoor unit

(NOTE: All power supply wiring should be installed in accordance with the National Electrical Code requirements.)

O. Install the outdoor thermostats

P. Have your instructor evaluate the installation

Date______________ By____________________________

Q. Pressurize the heat pump system and leak check

R. Charge the system with refrigerant as instructed

S. Turn the heat pump to the cool cycle and check performance

T. Have your instructor evaluate your progress at this time

Date______________ By___________________________

U. Return all unused materials and supplies to storage

V. Return all tools and equipment to their assigned areas

W. Clean up your installation site

SOLAR ASSISTED HEAT PUMP SYSTEMS
UNIT II.

JOB SHEET #3--INSTALL A STORAGE/TERMINAL LOOP

I. Tools, materials and components

A. Basic hand tools

B. Torch outfit

C. Silver bearing solder

D. Flux for solder

(NOTE: Other types of soft solder may be specified by the instructor, such as 50/50, 95/5, etc.)

E. Thermal storage tank with heat exchanger

F. Globe valve, if required

G. Motorized 2-position diverter valve

H. Hydronic solar heating coil

I. Circulator pump

J. Main control package for total system operation

K. Wiring materials and supplies for power and low voltage wiring

L. Expansion tank

M. Required valves, pipe, fittings, insulation, supports, etc.

II. Procedures

A. Assemble all components, tools and materials

B. Locate the thermal storage tank

C. Locate the circulator pump

D. Locate the expansion tank

E. Install the required pipe, valves, pipe insulation, and supports

(NOTE: Do not connect the expansion tank at this time.)

F. Insulate the thermal storage tank, if required

G. Have your instructor evaluate the installation

Date______________ By___________________________

H. Leak test the system

(NOTE: Testing should be done with the expansion tank disconnected to prevent possible damage to the diaphragm.)

I. Install the expansion tank

J. Install water supply piping to system

K. Fill the system as outlined in the installation instructions

L. Install the tank sensor

M. Install the power supply for the circulator pump

N. Install wiring to the motorized 2-position diverter valve

O. Fill the collector loop with selected heat transfer fluid

(NOTE: Follow installation instructions carefully when filling the collector loop to avoid spilling toxic fluids.)

P. Have your instructor evaluate progress at this time

Date______________ By___________________________

Q. Install the main control package for total system operation

R. Have your instructor check the installation and wiring

Date______________ By___________________________

S. Check operation of the collector loop

T. Check operation of the storage/terminal loop

U. Check operation of the heat pump in the heating mode

(NOTE: If the outdoor temperature is below 68°F, check with your instructor on the length of operation of the heat pump.)

V. Check operation of the first stage resistance heater

(NOTE: These checks may require the jumpering of thermostats and should be done only under the supervision of the instructor.)

W. Check operation of any override controls

X. Have your instructor evaluate your performance

Date______________ By____________________________

Y. Turn the water supply valve to off

Z. Turn off all power to the system and lock the disconnect switches

AA. Return all unused materials and supplies to storage

BB. Return all tools and equipment to their assigned areas

CC. Clean up your installation site

SOLAR ASSISTED HEAT PUMP SYSTEMS

JOB SHEET #4--INSTALL A DOMESTIC WATER HEATER PREHEAT LOOP

I. Tools, materials and components

A. Basic hand tools

B. Torch outfit

C. Selected solder and flux

D. Domestic hotwater tank with auxiliary electric heater element

E. Two adjustable mixing valves

F. Two check valves

G. Three gate valves

H. Copper pipe and fittings

I. Pipe insulation

J. Electrical wiring and supplies for heater element

K. Pipe supports

II. Procedures

A. Assemble all components, materials and tools

B. Locate the domestic hotwater tank

C. Install the city water supply line to a gate valve

D. Install the piping, check valves, gate valves, and pipe insulation in the supply water line to the heat exchanger in the thermal storage tank

E. Install the pipe, check valve and pipe insulation in the hotwater line to the domestic tank

F. Install the check valve and one adjustable mixing valve between the cold water supply and hot water line leaving the domestic tank

G. Install the second check valve and adjustable mixing valve between the cold water supply to the heat exchanger and hot water line to the domestic tank

(NOTE: This valve should be adjusted to about 140°F to prevent high temperature water being supplied to the domestic tank from thermal storage.)

H. Install the electrical wiring to the electric heating element in the domestic tank

(NOTE: Wiring should meet National Electrical Code standards for water heaters.)

I. Leak check the preheat loop

J. Check temperature of water leaving the two mixing valves

(NOTE: The mixing valve suppling water for household use should be ajusted to 120°F for safe use.)

K. Have your instructor evaluate your performance

Date______________ By___________________________

L. Turn off power to the electric heater element circuit and lock the disconnect switch

M. Return all unused materials and supplies to storage

N. Return all tools and equipment to their assigned areas

O. Clean up your installation site

SOLAR ASSISTED HEAT PUMP SYSTEMS
UNIT II

NAME_____________________________

TEST

1. Match terms on the left to their correct definitions

_____a. Auxiliary system
_____b. Caulking
_____c. Collection
_____d. Design temperature
_____e. Double-glazed
_____f. Flow rate
_____g. Galvanic corrosion
_____h. Glazing
_____i. Header
_____j. Heat distribution
_____k. Heat gain
_____l. Infiltration
_____m. Resistance heating
_____n. Heat loss
_____o. Heat storage
_____p. Space heating
_____q. Utraviolet radiation
_____r. Specific heat
_____s. Vapor barrier
_____t. Stagnation temperature

1. The act of conveying solar heat from collectors to areas to be heated
2. The pipe that runs across the edge of an array of solar collectors distributing the heat transfer fluid to or from risers in the individual collectors
3. A covering of transparent material used for admitting light
4. The condition caused by contact of two different metals not properly isolated
5. Collector that is covered with two layers of glass or other transparent material
6. The amount of heat transfer fluid that passes through the collector or storage loop in a selected time frame
7. Making an airtight seal by filling in cracks around windows and/or doors

8. A supplementary heating unit to provide heat to a space when the solar system cannot meet the demand

9. The act of trapping solar radiation and converting it to heat

10. A designated temperature used in estimating a building's heating and/or cooling requirements

11. A standard method of coverting electricity into heat

12. An increase in the amount of heat contained in a space

13. Medium that absorbs collected solar heat and holds it until needed

14. The uncontrolled movement of outdoor air into the conditioned space

15. Plastic sheeting that is used to prevent condensation in walls and other locations of insulation

16. A decrease in the amount of heat contained in a space

17. Heating of the air inside a building

18. High temperature reached inside a collector when the heat transfer fluid is not circulating on sunny days

19. Radiation that has a deteriorating effect on unprotected pipe insulation and other exposed materials

20. The number of Btu's required to raise the temperature of one pound of water 1°F

2. List three forms of energy a solar assisted heat pump is designed to utilize.

   a. ________________________________

   b. ________________________________

   c. ________________________________

3. List four types of energy to be considered in managing energy resources.

   a. ________________________________

   b. ________________________________

   c. ________________________________

   d. ________________________________

4. List four areas of consideration in calculating solar requirements.

   a. ________________________________

   ____

   b. ________________________________

   ____

   c. ________________________________

   ____

d. ____

____

5. Match three terms related to calculating a solar system output to their correct definitions.

_____a. Capacity of the solar radiant heat collection system

_____b. Net monthly Btu output is utilized to

_____c. Net output rating for each month reflects

1. Calculate the required collector surface needed for a specific application

2. The proportion of radiant energy which the collector can transform into usable Btu's

3. Is based on the net Btu output of each collector panel for each winter month for the selected location

6. State the recommended capacity for storing energy for a solar assisted heat pump and list three design considerations.

a. Recommended capacity--__________________________

____

b. Three design considerations

1) ____

____

2) ____

____

3) ____

____

7. Select three solar components that are generally available from solar suppliers only by placing an "X" in the appropriate blanks.

_____a. Flat plate collectors

_____b. Vacuum tube collectors

_____c. Hydronic solar heating coil unit

_____d. Circulator pumps

_____e. Heat exchangers

_____f. Motorized two-position diverter valves

_____g. Valves, fittings, expansion tanks, pipes, etc.

_____h. Thermal storage tanks

_____i. Differential thermostats

_____j. Control sensors

8. Match terms related to heating phases of a solar assisted heat pump to their correct deffinitions.

_____a. First heat phase

_____b. Second heat phase

_____c. Third heat phase

_____d. Fourth heat phase

_____e. Automatic control switching

1. When the first balance point is reached, the solar subsystem is again turned on to provide auxiliary heat to support the capacity of the heat pump

2. The solar subsystem should have the capacity to supply needed heat between 68°F to 47°F except in periods of overcast or cloudy weather

3. At 47°F the solar subsystem is turned off by some manufacturers and the reverse cycle heat pump is turned on

4. Brings on first stage of electric resistance heat

5. Will revert the system to first heat phase regardless of outdoor temperature if the solar storage temperature reaches 180°F

9. List two characteristics of a solar assisted heat pump in summer operation for a heat pump system and a solar subsystem.

   a. Heat pump system

      1) ______________________________

      ____

      2) ______________________________

      ____

   b. Solar subsystem

      1) ______________________________

      2) ______________________________

10. Discuss a domestic solar hotwater loop preheat piping circuit in three statements.

a. ____

____

b. ____

____

____

c. ____

____

____

11. Match three functions of the collector loop with their correct components.

___a. Serves as a means of transferring the collected solar energy from the collector loop to the storage/terminal loop

___b. Pumps the heat transfer fluid through the collectors and heat exchanger

___c. Converts solar radiation into thermal energy

1. Solar Collector panels

2. Heat exchanger

3. Circulator pump

12. Match the components in the storage/terminal loop of a solar assisted heat pump system to their correct functions.

___a. Circulator

___b. Thermal storage tank

___c. Hydronic coil

___d. Motorized 2-position diverter valve

___e. Bypass valve

1. Provides a means for the use of hot water to heat air from the conditioned space

2. Is activated each time the collector loop pump is running

3. Provides means of preheating water for the domestic hot water tank

4. A globe valve installed in the discharge side of the hydronic coil

5. Directs hot water directly to the thermal storage tank during second heat phase

13. Match the components in the heat pump loop of a solar assisted heat pump system to their correct functions.

___a. Outdoor unit

___b. Indoor coil unit

___c. Electric resistance heaters

___d. Indoor air handler

1. Absorbs heat from the outdoor air during the heating mode and transports the collected heat to the indoor coil unit

2. Provides Housing and support for the indoor coil, blower motor, fan and the resistance heater strips

3. Heat absorbed in the outdoor unit is transferred from the indoor coil to the circulating conditioned space air

4. Provide auxiliary heat source to supplement the heat pump and solar system

14. List an accepted method of calculating heating requirements with a heat gain/heat loss study.

a. ______________________________

____

15. Name four types of individuals qualified to design a solar assisted heat pump system.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

16. List the method of rating collectors in net monthly output.

a. ______________________________

17. List four kinds of information provided by the monthly output data sheet on collectors.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

18. State the priority consideration in the physical orientation of flat plate collectors.

a. ______________________________

____

____

19. Match statements related to collector tilt and orientation of flat plate collectors to their correct terms.

_____a. Collector tilt

_____b. Collector orientation

1. Collectors can face from 15° to 20° east or west of true south without significant loss of output in most flat plate collectors

2. The collectors should be tilted above the horizon 12° to 15° more than the degree of latitude at the installation site

20. State two precautions related to the installation of flat plate collectors.

a. ______________________________

____

____

____

b. ______________________________

____

____

21. List three methods of circuiting collectors.

a. ______________________________

____

b. ______________________________

____

c. ______________________________

____

22. List two statements related to sizing of copper pipe in a solar system.

a. Tubing size--______________________________

____

b. Equivalent feet of tubing for fittings--__________

____

____

23. List two statements related to sizing of the collector loop pump and piping.

a. Pump--______________________________

____

b. Piping--______________________________

____

24. State the purpose of the expansion tank in a closed loop sytem.

a. ______________________________

____

25. Select components common to collector loops by placing an "X" in the appropriate blanks.

_____a. Check valve

_____b. Automatic float type air vent

_____c. Expansion valve

_____d. Automatic regulating valve

_____e. Balancing valve

_____f. Pressure relief valve

_____g. Drain valve

_____h. Drain and fill valve

_____i. Back flow preventer valve

26. State the purpose of antifreeze in the heat transfer fluid and list the percentage of water and glycol solution used to provide a minus 32°F freeze protection.

a. Purpose of the antifreeze--____________________

____

b. Solution mixture--__________________________

27. State the instructions related to filling the collector loop with transfer fluid.

a. ____

____

28. Describe two functions of the collector loop heat exchanger.

a. ____

____

b. ____

____

29. Select components in the storage/terminal loop by placing an "X" in the appropriate blanks.

_____a. Automatic purge valve

_____b. Expansion tank

_____c. Solenoid valve

_____d. Thermal storage tank

_____e. Hydronic solar heating coil

_____f. Reversing valve

_____g. Inverted valve

30. Select the recommended size for a 30 ft. run of copper pipe for the terminal and storage loop from Transparency 22.

a. Terminal loop with 6 Gpm flow rate _____________

b. Storage loop with 6 Gpm flow rate _____________

31. Select components in a domestic hotwater loop by placing an "X" in the appropriate blank.

_____a. Hotwater tank

_____b. Air purge valve

_____c. Heat exchanger

_____d. Freeze override sensor

_____e. Reverse flow valve

_____f. Check valve

_____g. Gate valve

_____h. Globe valve

_____i. Auxiliary water heater element

_____j. Cooling valve

_____k. Mixing valve

32. Select components in the system control package by placing an "X" in the appropriate blank.

_____a. Indoor thermostat

_____b. Main control panel

_____c. Liquid storage thermostats

_____d. Fan limit switch

_____e. Branch circuit fuses

_____f. Outdoor thermostat

_____g. Balance point thermostat

_____h. Low pressure switch

_____i. Differential temperature thermostat

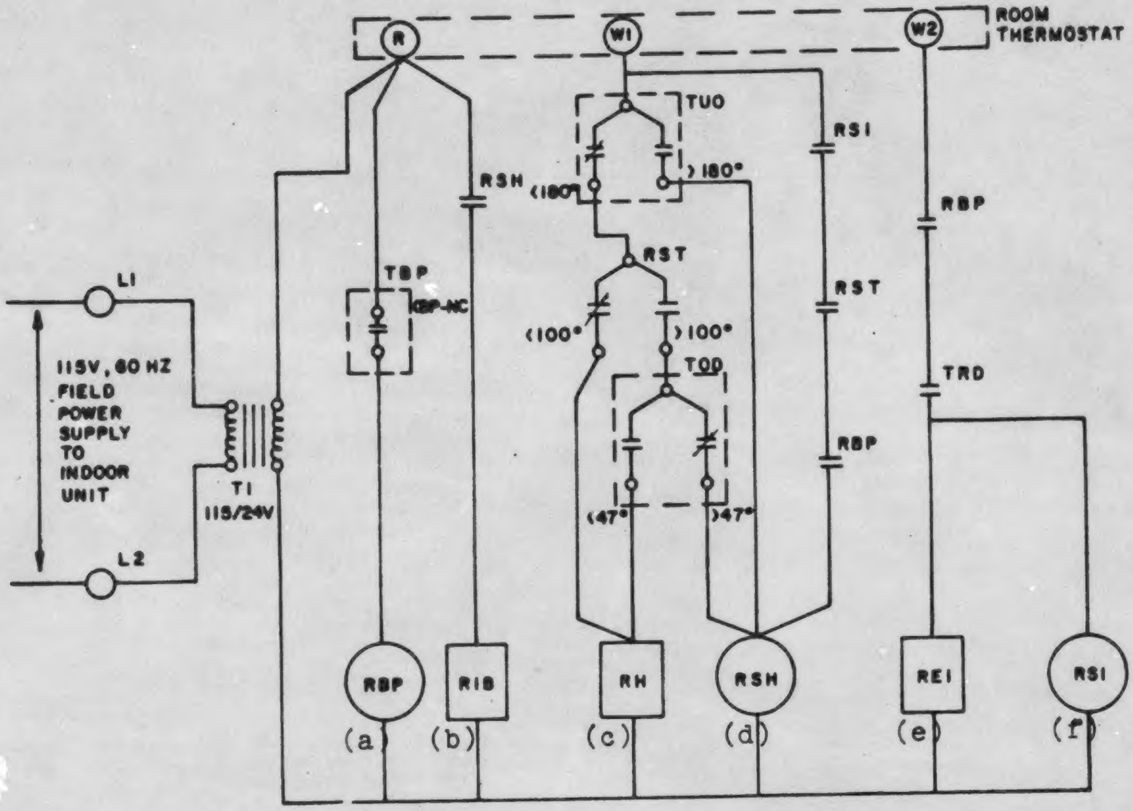
_____j. Clock timer for heat only

_____k. Time delay solar interlock relay

33. List the number of functions simulated by the system operation analysis sheet on Transparency 26.

a. ____

34. Identify six low voltage loads illustrated in the solar diagram below from the legion.



a. ____

b. ____

c. ____

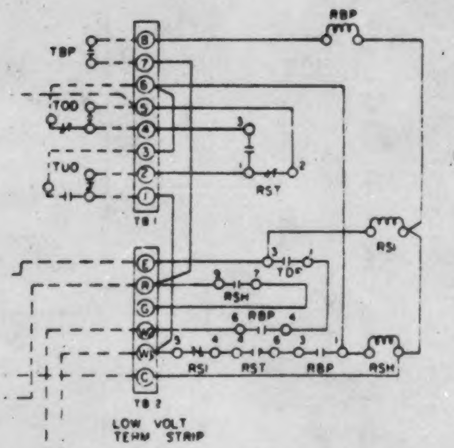
d. ____

e. ____

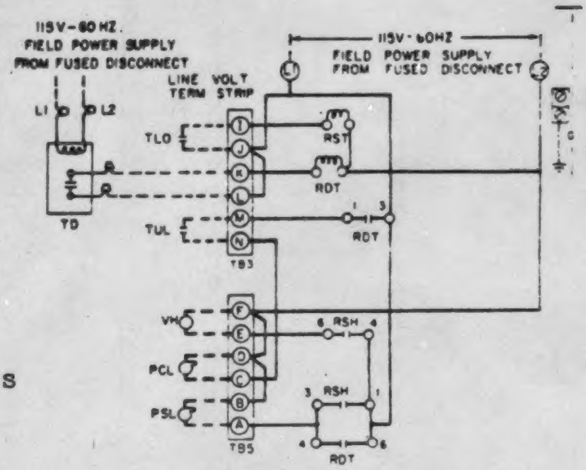
f. ____

PCL	COLLECTOR LOOP PUMP
PSL	STORAGE/TERMINAL LOOP PUMP
RBP	BALANCE POINT RELAY
RD	DEFROST RELAY
RDT	DIFFERENTIAL THERMOSTAT RELAY
RE1	ELECTRIC HEATER RELAY
RH	HEAT RELAY
RIB	RELAY INDOOR BLOWER
RSH	SOLAR HEAT RELAY
RSI	SOLAR INTERLOCK RELAY
RST	STORAGE, TEMPERATURE RELAY
TBP	BALANCE POINT THERMOSTAT
TD	DIFFERENTIAL THERMOSTAT
TDR	TIME DELAY RELAY
TLO	LIQUID STORAGE LOWER OPERATING THERM.
TOD	OUTDOOR THERMOSTAT
TUL	LIQUID STORAGE UPPER LIMIT THERM
TUO	LIQUID STORAGE UPPER OPERATING THERM.
VH	HYDRONIC CONTROL VALVE

35. Identify three low voltage loads in the solar wiring diagram and six high voltage loads in the heat pump circuit below.



a. Low Voltage Loads


115V-60HZ. FIELD POWER SUPPLY FROM FUSED DISCONNECT
L1
L2
TD
LINE VOLT TERM STRIP
115V-60HZ FIELD POWER SUPPLY FROM FUSED DISCONNECT
TLO
RST
RDT
TUL
RDT
TB3
VH
RSH
PCL
PSL
RSH
RDT
TB5

b. High Voltage Loads

Legend

AHC	AUXILLIARY HEATER CONTROL
Cc	COMPRESSOR CONTACTOR
DT	DEFROST TIMER
FL	FUSIBLE LINK
IBM	INDOOR BLOWER MOTOR
LCP	LOSS OF CHARGE PROTECTOR
O-|/|-O	NORMALLY CLOSED CONTACTS
O-| |-O	NORMALLY OPEN CONTACTS
O—⌒—O	OPEN ON TEMP RISE
O—⌒—O	CLOSE ON TEMP DROP
OFM	OUTDOOR FAN MOTOR
PCL	COLLECTOR LOOP PUMP
PSL	STORAGE/TERMINAL LOOP PUMP
RBP	BALANCE POINT RELAY
RD	DEFROST RELAY
RDT	DIFFERENTIAL THERMOSTAT RELAY
RE 1	
RE 2	ELECTRIC HEATER RELAYS
RE 3	
RH	HEAT RELAY
RIB	RELAY INDOOR BLOWER
RSH	SOLAR HEAT RELAY
RSI	SOLAR INTERLOCK RELAY
RST	STORAGE, TEMPERATURE RELAY
TBP	BALANCE POINT THERMOSTAT
TD	DIFFERENTIAL THERMOSTAT
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TOO	OUTDOOR THERMOSTAT
TUL	LIQUID STORAGE UPPER LIMIT THERM
TUO	LIQUID STORAGE UPPER OPERATING THERM
VH	HYDRONIC CONTROL VALVE
DTM	DEFROST TIMER MOTOR
RC	RUN CAPACITOR

a. Low voltage loads

1) ______________________________

2) ______________________________

b. High voltage loads

1) ______________________________

2) ______________________________

3) ______________________________

4) ______________________________

5) ______________________________

6) ______________________________

36. Demonstrate the ability to:

   a. Isolate solar heat circuits only in a wiring diagram

   b. Isolate heat pump circuits only in a wiring diagram

   c. Isolate relays, contacts, and motors for heat pump operation with solar sub-system support

   d. Isolate heat pump, first and second stage resistance heater circuits only, in a wiring diagram

   e. Install a collector loop for a solar assisted heat pump

   f. Install a split-heat pump system

   g. Install a storage/terminal loop

   h. Install a domestic water heater loop

(Note: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

SOLAR ASSISTED HEAT PUMP SYSTEMS
UNIT II

NAME ______________________________

ANSWERS TO TEST

1.	a.	8	h.	3	o.	13
	b.	7	i.	2	p.	17
	c.	9	j.	1	q.	19
	d.	10	k.	12	r.	20
	e.	5	l.	14	s.	15
	f.	6	m.	11	t.	18
	g.	4	n.	16		

2. a. Radiant solar energy
   b. Reverse cycle heat pump
   c. Electric resistance heat

3. a. Fossil fuels
   b. Radiant solar energy
   c. Reverse cyle heat pump
   d. Electric resistance heat

4. a. Efficient utilization of established data on selected collector plates
   b. Adjustment for changes in collector effective solar incidence for selected area
   c. Identification of specific structure heat loss to be replaced by solar radiant heat
   d. Established data on method of storing collected solar heat

5. a. 3
   b. 1
   c. 2

6. a. Limited to practical, meaningful proportions

   b. 1) Designed principally to cover the daily requirements of the heat pump for supplementary heat below the first balance point

      2) Designed to limit the need for resistance heat required below the balance point operation

      3) Designed to make a most important contribution to operating economy by substituting low cost stored solar energy for electric resistance heat

7. b, i, j

8. a. 2

   b. 3

   c. 1

   d. 4

   e. 5

9. a. Heat pump system

      1) Indoor thermostat system switch is adjusted to the cool position

      2) The heat pump performs as an air conditioner only

   b. Solar subsystem

      1) Used to heat water in hotwater tanks

      2) Used to heat water in swimming pools

10. a. Cold supply water is circulated through a heat exchanger in the thermal storage tank

    b. Heated water from the heat exchanger is piped into the cold water inlet of the domestic hotwater tank

    c. Hot water from the domestic tank is piped through a mixing valve, then to use points

11. a. 2

b. 3

c. 1

12. a. 2

b. 3

c. 1

d. 5

e. 4

13. a. 1

b. 3

c. 4

d. 2

14. a. Use the NESCA Manual "J" procedures on a NESCA J-1 Form

15. a. Trained solar engineer

b. Trained solar technician

c. Trained distributor engineer

d. Trained factory representative

16. a. Rated in thousands of Btu's per hour (MBTU)

17. a. Degree north latitude

b. Location of different installation sites

c. Collector tilt recommended for each location

d. Information on output for a seven month period

18. a. Priority consideration should be given to the change of angle in the sun's path of travel from winter maximum to summer maximum

19. a. 2

b. 1

20. a. Collectors should be mounted on roofs with spacers that will permit water to drain off and to provide ventilation under the panels to dry roof materials

b. Protect all metal parts from electrolic action by insulating dissimilar metals from direct contact with each other

21. a. Six to seven collectors can be connected in series to form a group

b. Series connected groups of collectors can be arranged in parallel to form an array or bank

c. The number of collectors in each group should be the same to insure uniform flow rates

22. a. Tubing size--Determined by the volume of fluid to be moved and the "equivalent length" of the circuit

b. Equivalent feet of tubing for fittings--The total length of tubing designed into each collector loop should represent allowances for loss due to fittings and valves in the circuit

23. a. Pump--Should maintain the designed flow rate for a bank of several collectors

b. Piping--Should be selected to match the designed capacity of pump and loop

24. a. To handle changes in pressure and volume which occur with changes in fluid temperature in closed loop systems

25. a, b, e, f, g, h

26. a. Purpose--Used to prevent freezing or boiling of water in the collector loop

b. Solution mixture--50% water to 50% ethylene glycol

27. a. Should be filled according to the equipment manufacturer's installation instructions

28. a. To serve as a contact vessel between the storage loop and collector loop heat transfer fluids

b. To protect the storage/terminal loop water from contact with the toxic transfer fluid

29. b,d,e

30. a. 3/4"

    b. 3/4"

31. a,c,f,g,i,j,k

32. b,c,f,g,i,k,

33. 8

34. a. Balance point relay

    b. Indoor blower relay

    c. Heat relay

    d. Solar heat relay

    e. Electric heat relay

    f. Solar interlock relay

35. a. 1) Balance point relay

       2) Solar interlock relay

       3) Solar heat relay

    b. 1) Differential thermostat

       2) Storage temperature relay

       3) Differential thermostat relay

       4) Collector loop pump

       5) Storage/terminal loop pump

       6) Hydronic control valve

36. Performance skills evaluated to the satisfaction of the instructor

SOLAR ABSORPTION SYSTEMS
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with solar absorption air conditioning to their correct definitions or descriptions. The student should also be able to identify system components, match their functions to heating and cooling modes, and install an absorption chiller system. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with solar absorption air conditioning to their correct definitions or descriptions.
2. List two manufacturers of solar absorption chillers for domestic air conditioning systems.
3. List the type of refrigerant and absorption solution used with solar absorption systems.
4. Match components on the Solaire PWF 36-100 to their correct function.
5. List two requirements to be considered in selection of collectors for a solar absorption system.
6. Select required performance data for the WF-36 chiller.
7. Match components used in the PWF 36-100 cooling mode to their correct function.
8. Select components to be piped in a typical plumbing run for the PWF 36-100.
9. Match components of the hydronic coil to their correct function.
10. Select the components used in the PWF 36-100 heating mode.

11. Match WF-36 switches and controls to their correct function.

12. Discuss the location and purpose of thermometer wells on the WF-36 chiller.

13. Discuss the characteristics of wiring diagrams and schematic diagrams.

14. Select specifications listed on the WF-36 specification data sheet.

15. List seven components used in the Yazaki Solar absorption system cooling mode.

16. List five components used in the Yazaki Solar absorption system heating mode.

17. Match sequence of operation of an absorption system in the cooling and heating mode.

18. List in order the four basic cycle stages in a water/lithium bromide absorption chiller.

19. Match the four basic sequence stages of a water/lithium bromide absorption chiller to their correct definition.

20. Demonstrate the ability to:

    a. Identify piping runs used in a solar fired absorption heat/cool system in the cooling mode.

    b. Identify piping circuits and components used in the heating mode of a solar fired absorption heat/cool system.

    c. Identify piping circuits and components used in the cooling mode of an absorption heat/cool system with auxiliary boiler "on".

    d. Identify piping circuits involved in the solar heat mode of an absorption heat/cool system with back-up boiler "off".

    e. Assemble a PWF 36-100 package unit and locate support components.

    f. Install piping circuits for an absorption heat/cool package system with drain back collector loop.

g. Install piping circuits for an absorption heat/cool system storage tank.

h. Install an evaporative cooling tower for an absorption heat/cool system.

i. Install a fan-coil unit for a solar absorption heat/cool system.

j. Install gas piping circuit for the back-up boiler of an absorption heat/cool system.

k. Install solar hotwater heater piping circuit.

l. Install power and control circuits for a solar absorption heat/cool system.

m. Start-up and check performance of an absorption heat/cool system.

SOLAR ABSORPTION SYSTEMS
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet

  B. Provide student with information, assignment, and job sheets

  C. Make transparencies

  D. Discuss unit and specific objectives

  E. Discuss information and assignment sheets

  F. Review transparencies with class

  G. Discuss test procedures

  H. Review selected films and slides with class

  J. Give test

II. Student:

  A. Read objective sheet

  B. Study information sheets

  C. Complete assignment sheets

  D. Take test

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheets

  C. Transparency masters

    1. TM 1--Solaire Model PWF 36-100

    2. TM 2--Solaire Model PWF 36-100 (Continued)

    3. TM 3--Performance Data for WF-36

4. TM 4--PWF 36-100 Cooling Mode
5. TM 5--Typical Plumbing Runs
6. TM 6--Hydronic Coil and Controls
7. TM 7--PWF 36-100 Heating Mode
8. TM 8--WF-36 Switches and Controls
9. TM 9--WF-36 Thermometer Well Location
10. TM 10--Electrical Circuits for PWF 36-100
11. TM 11--Specifications for Solaire WF-36
12. TM 12--Yazaki Solar Absorption System

D. Assignment sheets

1. Assignment Sheet #1--Identify Piping Runs Used in a Solar Fired Absorption Heat/Cool System in the Cooling Mode
2. Assignment Sheet #2--Identify Piping Circuits and Components Used in the Heating Mode of a Solar Fired Absorption Heat/Cool System
3. Assignment Sheet #3--Identify Piping Circuits and Components Used in the Cooling Mode of an Absorption Heat/Cool System with Auxiliary Boiler "On"
4. Assignment Sheet #4--Identify Piping Circuits Involved in the Solar Heat Mode of an Absorption Heat/Cool System with Back-Up Boiler "Off"

E. Answers to assignment sheets

F. Job sheets

1. Job Sheet #1--Assemble a PWF 36-100 Package Unit and Locate Support Components
2. Job Sheet #2--Install Piping Circuits for an Absorption Heat/Cool Package System with Drain Back Collector Loop
3. Job Sheet #3--Install Piping Circuits for an Absorption Heat/Cool System Storage Tank

4. Job Sheet #4--Install an Evaporative Cooling Tower for an Absorption Heat/Cool System

5. Job Sheet #5--Install a Fan-Coil Unit for a Solar Absorption Heat/Cool System

6. Job Sheet #6--Install Gas Piping Circuit for the Back-Up Boiler of an Absorption Heat/Cool System

7. Job Sheet #7--Install Solar Hotwater Heater Piping Circuit

8. Job Sheet #8--Install Power and Control Circuits for a Solar Absorption Heat/Cool System

9. Job Sheet #9--Start-Up and Check Performance of an Absorption Heat/Cool System

G. Test

H. Answers to test

II. References

A. ARKLA Installation and Start-Up Manual for a PWF 36-100 Package Unit, ARKLA Industries, Inc., P.O. Box 534, Evansville,Indiana 47704, 1976

B. Yazaki Corporation, Head office, 17th fl. Mita-Kokusai Bldg., 4-28, 1-chome, Mita, Minato-Ku, Tokyo, Japan

SOLAR ABSORPTION SYSTEMS
UNIT III

INFORMATION SHEET

I. Terms and definitions

  A. Change of state--The physical form of matter changes from solid to liquid or liquid to gas

  B. Concentrating collector--A class of collectors that use reflector surface to focus solar radiation on a small area

  C. Linear concentrating collector--A type of concentrating collector, oblong in shape, which focuses the reflected radiation onto a tube absorber

  D. Thermosiphoning--The principle that heated gases and liquids rise naturally

  E. Absorbent--A liquid which combines chemically with a refrigerant

  F. Refrigerant--Working fluid in a refrigeration system

  G. Coefficient of performance (COP)--Ratio of removal rate to heat supply rate

  H. Ton of refrigeration--Heat removal at a rate of 12,000 Btu's per hour

  I. Evacuated tube collector--Collector with a vacuum surrounding the absorber to reduce losses by conduction and convection

II. Manufacturers of solar absorption chillers for domestic air conditioning systems

  A. ARKLA Industries, Inc.--ARKLA Solaire Systems

  B. YAZAKI Corporation--YAZAKI Solar Systems

III. Types of refrigerant and absorption solution used with solar absorption chillers

  A. Type refrigerant--Water

  B. Type absorption solution--Lithium bromide

IV. ARKLA Solaire Model PWF 36-100 component functions--Transparency 1 and 2

A. Components--Front view of package

1. Control panel--Provides unit operating and safety controls, power and connection points for system operating relays

2. Circuit breakers--Provide on site interruption of power to the system and protection to individual load circuits

3. Generator input control valve--Controlled by the generator control relay during the cooling mode

   (NOTE: This is a three-way valve and is moved by a proportional hydraulic actuator with spring return feature.)

4. Chiller--Contains the condenser, evaporator, generator, solution control chamber and absorber

   (NOTE: Lithium Bromide is the absorption solution and water is used as the refrigerant.)

5. Systems tank--Provides a drain-back reservoir for fluids in the various circuits

6. Flow switch--Allows the gas valve to open after water flow through the boiler has been established

7. Relief valve--Pressure/temperature relief valve to prevent possible overheating of water in boiler

   (NOTE: Local codes will generally require that this valve be vented to safe discharge area.)

8. Auxiliary boiler--Provides a source of heat to supplement solar heat or provide total heat for the heating or cooling modes

9. Boiler exhaust vent--Provides means of exhausting fumes to the outside

10. Boiler Hi-limit control--Controls burner operation in both heating and cooling modes if the boiler outlet temperature reaches 200°F

(NOTE: This is an automatic reset safety limit switch and must not be bypassed.)

11. Boiler gas valve--Solenoid controlled valve that serves as a shut-off valve when the boiler is not needed

12. Burner modulation control--Varies gas input to the burner to provide desired output

    (NOTE: For use with natural gas only.)

13. Generator pump--Provides the absorption chiller with hot water from the systems' tank

    (NOTE: Temperature of water delivered to the generator will determine output of unit in the cooling mode.)

14. System vent--Provides venting of air from the systems tank to outdoors

    (NOTE: Care should be taken to prevent plugging or restricting this vent.)

15. Fan coil pump--Provides circulation of chilled or heated water through the fan coil unit

    (NOTE: Pumps may be connected in series to provide greater capacity.)

16. Domestic hotwater heater pump--Circulated hot water from systems tank through heat exchanger in DHW heater

17. Auxiliary boiler pump--Circulates water from the systems tank to the boiler and back to systems tank, when the auxiliary boiler is used to provide backup for the solar collectors

18. Collector pump--Circulates water from the main storage tank to the solar collectors

19. Systems tank water level gauge--Indicates level of water in systems tank

V. Collector selection requirements for the PWF 36-100 unit

A. When grouped, must be capable of supplying hot water in the 170°F - 205°F range at the required flow rate

B. Must be able to operate in a drain back system

VI. Performance data for WF-36--Transparency 3

A. Hot water flow--Amount of hot water input to the chiller for cooling operation

B. Condensing water flow--Amount of water pumped to the condenser to meet design demand

C. Chilled water flow--Amount of water pumped to the chiller to maintain design performance of the hydronic coil unit

D. Chilled water leaving temperature--Difference between temperature of water entering the chiller and water leaving the chiller

(NOTE: A difference of ten degrees is the designed amount for the WF-36.)

VII. Function of components used in the PWF 36-100 solar cooling mode--Transparency 4

A. Solar collectors--Converts solar radiation into solar heat

B. Chiller--Provides chilled water to cool air from the conditioned space

C. Systems tank--Provides a drain-back reservoir for liquids in the various piping circuits

D. Fan-coil tank--Small volume tank serving as an air separation chamber for recirculating chilled water in the cooling mode

E. System vent condenser--Condensers hot vapors which otherwise would escape to the atmosphere

F. Fan-coil tank vent condenser--Condenses any hot vapor attempting to migrate to the chilled water in the fan-coil tank

G. Evaporative cooling tower--Designed to reject the full output of the absorption chiller at maximum design conditions

(NOTE: The cooling tower opeation is controlled automatically by the PWF 36-100 control system.)

H. Fan-coil unit--Hydronic coil equipped with a motorized 2-position diverter valve and fan blower

I. Solar domestic hotwater heater--Provides hot water for household use

(NOTE: This type installation will generally use a heater with external wrap-around type heat exchanger.)

J. Main storage tank--Sized to provide percentage of solar cooling desired during times when solar heat is not available

(NOTE: Size of storage could vary with each application.)

K. Heat-cool valve--Provides automatic changeover from cooling to heating or vice-versa on command from the room thermostat

L. Collector pump--Circulates water from main storage tank through the collector bank and back to the systems tank

M. Generator pump--Circulates hot water from the systems tank to the chiller unit generator circuit

N. Cooling tower pump--Circulates water from the chiller unit to the cooling tower

O. Domestic hotwater heater pump--Circulates water from the systems tank through a heat exchanger in the domestic hotwater tank

P. Generator control valve--Permits full flow of hot water to the generator or bypass flow back to the systems tank

(NOTE: This is a three-way valve that stops water input to the generator at 40°F and starts flow back to the generator at 43°F.)

Q. Auxiliary boiler--Supplements solar collection system as needed to maintain sufficient system tank temperature to meet the cooling load requirements

R. Fan-coil unit circulator pump--Circulates chilled water from the chiller to the hydronic coil

VIII. Typical plumbing run for the PWF 36-100--Transparency 5

A. Components to be piped

1. Main storage tank

2. Evaporative cooling tower

3. Fan-coil unit
4. Domestic hotwater heater
5. Collectors to storage tank
6. Collectors to systems tank
7. Collectors to expansion joints
8. Expansion joints to manifolds
9. Boiler-relief valve
10. Fan-coil condensate drain
11. Domestic hotwater relief valve vent
12. Cooling tower makeup water

(NOTE: Local codes may require that a licensed plumber install or supervise the installation of part or all piping for field installations.)

IX. Function of hydronic coil and controls--Transparency 6

A. Chilled water bypass valve--Used to bypass part of the fan-coil when temperature of the chilled water supplied to the coil reaches 49°F

(NOTE: Valve operates on a 3°F differential to reopen the valve at 46°F.)

B. Chilled water aquastat--Controls operation of the chilled water bypass valve

C. Fan delay control--Turns the fan motor on when the coil temperature reaches approximately 130°F and turns it off at approximately 100°F

(NOTE: This delay allows the coil temperature to reach a point where air delivered to the conditioned space will be warm.)

D. Fan relay--Controlled by the room thermostat to provide fan motor operation in the cooling mode

(NOTE: Continuous operation of the fan motor is possible with the fan subbase switch on the room thermostat.)

X. Components used in the PWF 36-100 heating mode--Transparency 7

   A. Auxiliary boiler

   B. Boiler circulator pump

   C. Systems tank

   D. Fan-coil unit circulator pump

   E. Heat/cool valve

   F. Fan-coil tank

   G. Fan-coil unit

   H. Domestic heater circulator pump

   I. Solar collectors

   J. Collector pump

XI. Function of WF-36 switches and controls--Transparency 8

   A. High temp switch--Will open to stop the flow of hot water to the generator, stop the chilled water circulator pump and shut off the chiller solution pump if the condenser surface temperature reaches 120°F ± 6°F

   (NOTE: Switch will automatically reset at 110°F ± 6°F; the unit should never be operated unless this switch is in place and functioning correctly.)

   B. Solution bypass valve--Functions to bypass weak solution away from the absorber coils to prevent flashing of refrigerant

   C. Solution bypass switch--Energizes the solenoid coil on the solution bypass valve when the evaporator coil temperature drops to 36°F ± 1°F

   D. Evaporator low temp limit switch--Interrupts hot water flow and condensing water flow through the unit if the coil temperature goes down to approximately 33° ± 1°F

   (NOTE: This switch is in the control wiring circuit for the external hotwater valve and cooling tower and will reset automatically with a 4°F temperature rise.)

XII. WF-36 Thermometer well location and purpose--Transparency 9

   A. Location--Located at the inlet and outlet connections of the hot, chilled and condensing water outlets

   B. Purpose--To provide location and means of checking operational temperatures of the chiller circuits

XIII. Electrical circuits for PWF 36-100--Transparency 10

   A. Wiring diagram--Identifies connection points for field installation of power supply wiring and 24 volt control circuits

   B. Schematic diagram--Makes it easy to identify individual circuit loads and switches

XIV. Specifications for Solaire WF-36--Transparency 11

   A. Design delivered capacity, Btu/h

   B. Design delivered capacity, Tons

   C. Energy requirements

   D. Chilled water data

   E. Condensing water data

   F. Cooling tower selection data

   G. Service connections

   H. Physical data, approximates

XV. Yazaki solar absorption system--Transparency 12

   A. Cooling mode components

      1. Flat plate collectors

      2. Storage tank

      3. Back-up boiler

      4. Hot water fired boiler

      5. Fan-coil unit

      6. Cooling tower

7. Collector loop circulator pump
8. Boiler pump
9. Fan-coil pump
10. Cooling tower pump

XVI. Yazaki solar absorption system--Transparency 12

A. Heating mode components

1. Flat plate collectors
2. Storage tank
3. Back-up boiler
4. Fan-coil unit
5. Collector loop pump
6. Boiler pump

XVII. Heating and cooling modes for a solar absorption chiller

A. Cooling

1. Solar heated water is supplied to the generator of the solar chiller
2. The hot water activates the generator to produce an absorption refrigeration cycle and chilled water
3. Chilled water is then pumped through the fan-coil unit to cool air from the conditioned space

B. Heating

1. Solar heated water is supplied directly to the fan-coil unit

(NOTE: The back-up boiler may be fired during cooling or heating modes to maintain the required water temperature.)

XVIII. Basic cycle stages of the water/lithium bromide absorption chiller

A. Divided into four basic stages

1. Regeneration
2. Condensation
3. Evaporation
4. Absorption

XIX. Four basic sequence stages of a water/lithium bromide absorption chiller

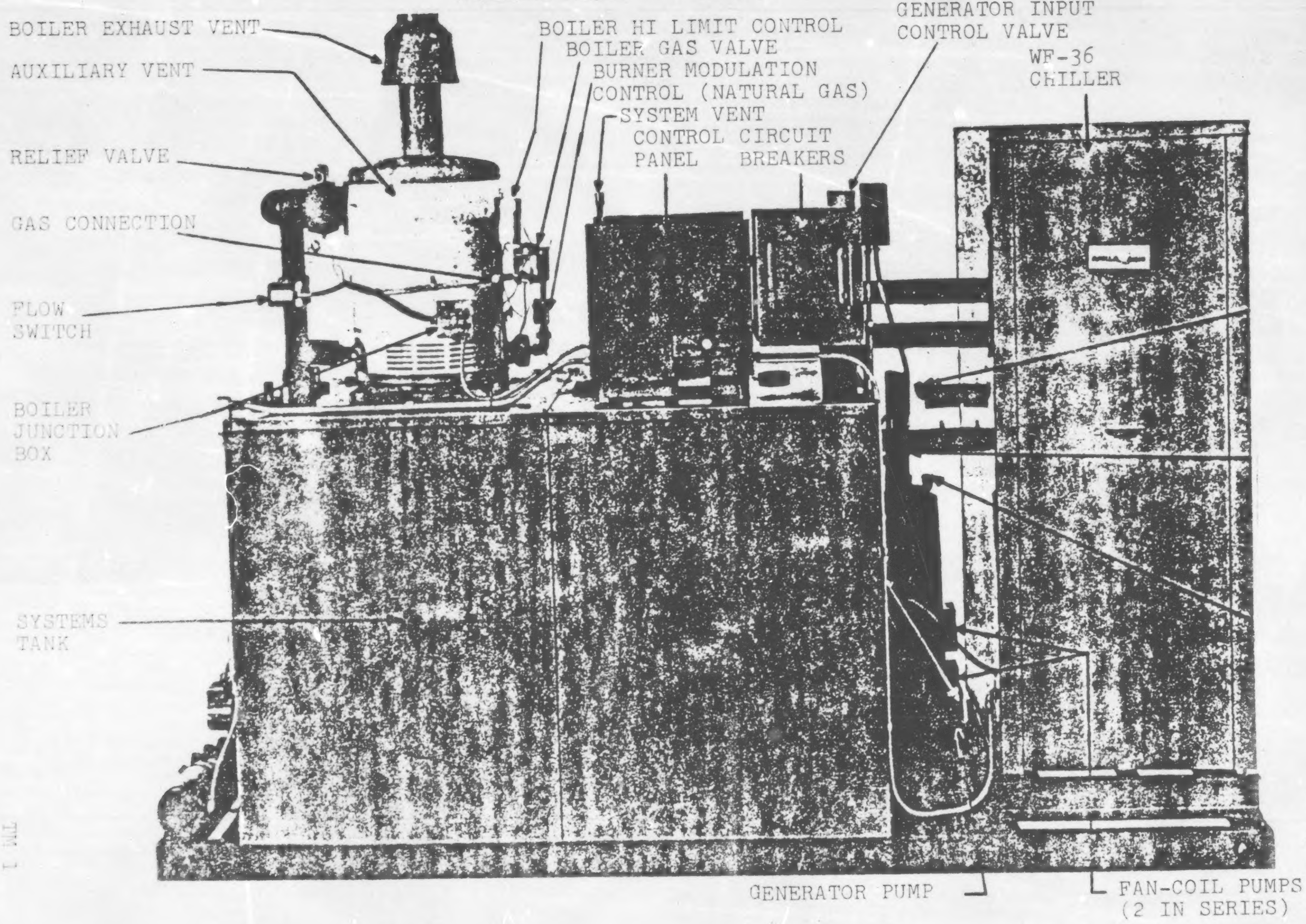
A. First stage--Solar heated water heats the lithium bromide solution to boiling point to produce a thick solution of lithium bromide and water vapor

B. Second stage--At the "condensation" stage, the water vapor is condensed by cooling water

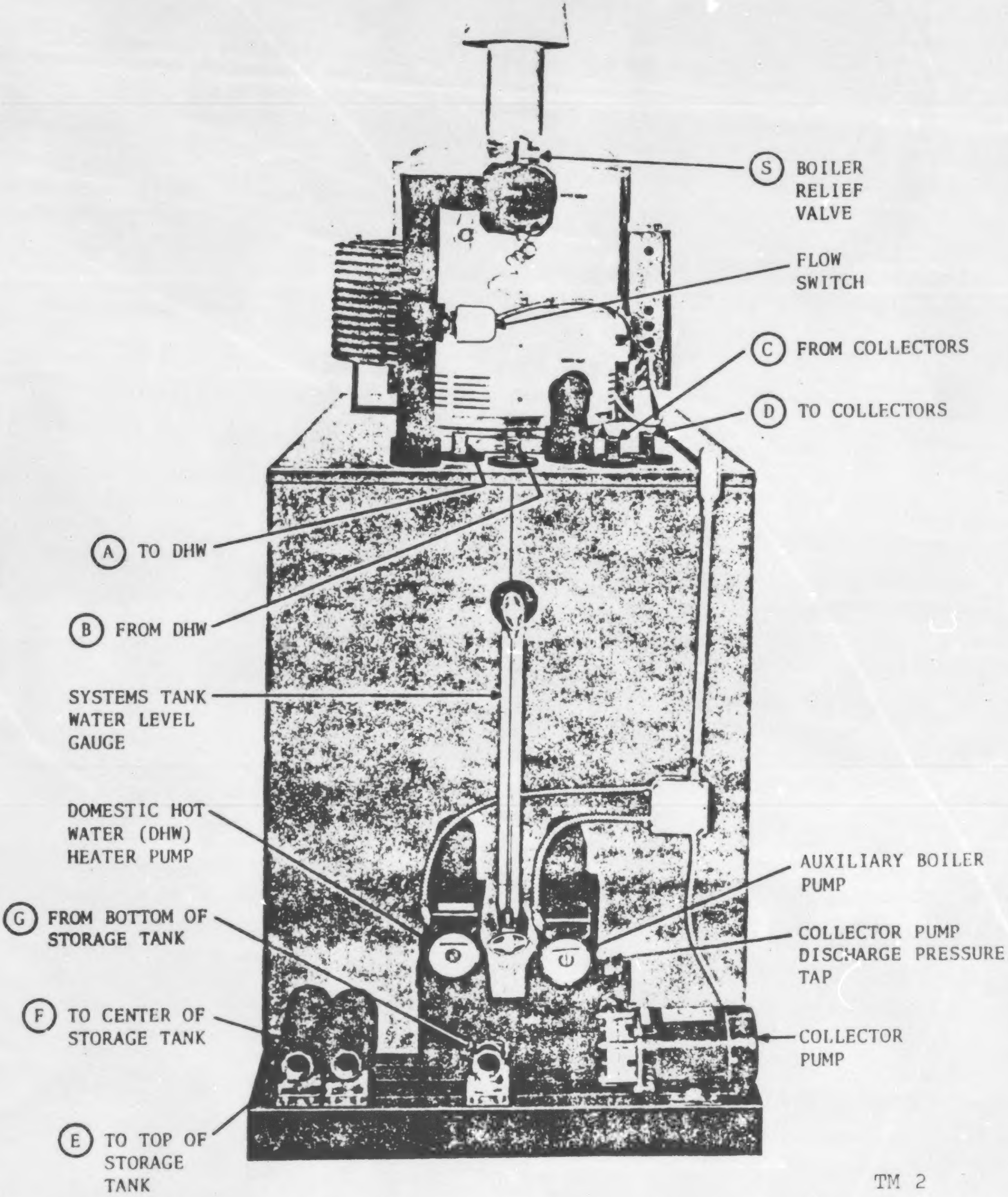
C. Third stage--The "evaporation" stage vaporizes the water condensed in the second stage in a vacuum and produces chilled water by--removing laten evaporation heat surrounding the coil

D. Fourth stage--At the "absorption" stage the thick lithium bromide solution obtained in the first stage is sprayed over the cooling water coil, absorbing the water vapor and producing chilled water in the coil-unit

SOLAIRE MODEL PWF 36-100



SOLAIRE MODEL PWF 36-100 (CONTINUED)


Ⓢ BOILER RELIEF VALVE
FLOW SWITCH
Ⓒ FROM COLLECTORS
Ⓓ TO COLLECTORS
Ⓐ TO DHW
Ⓑ FROM DHW
SYSTEMS TANK WATER LEVEL GAUGE
DOMESTIC HOT WATER (DHW) HEATER PUMP
AUXILIARY BOILER PUMP
Ⓖ FROM BOTTOM OF STORAGE TANK
COLLECTOR PUMP DISCHARGE PRESSURE TAP
Ⓕ TO CENTER OF STORAGE TANK
COLLECTOR PUMP
Ⓔ TO TOP OF STORAGE TANK

TM 2

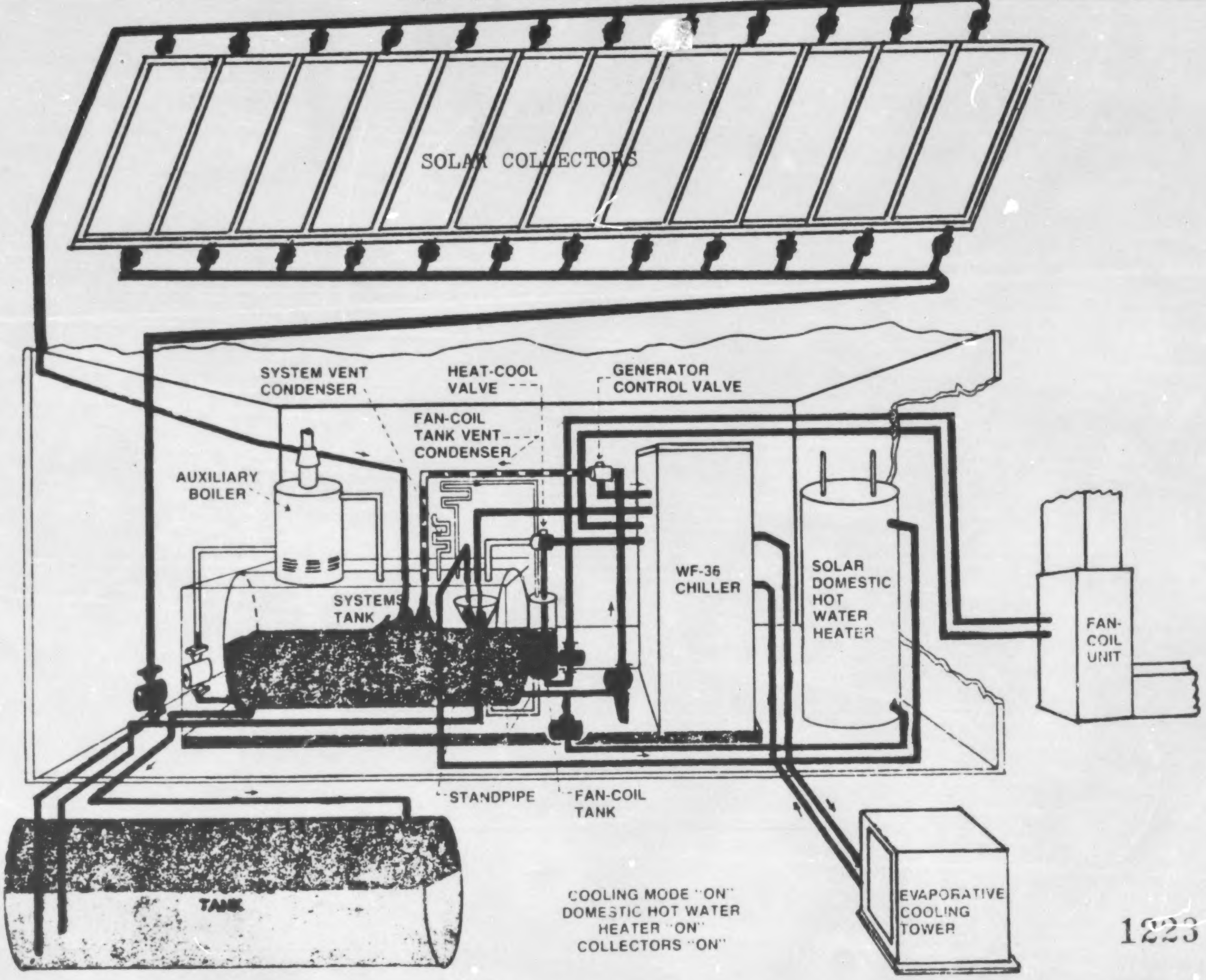
PERFORMANCE DATA FOR WF-36

Hot Water Flow . . . . 11.0 GPM
Condensing Water Flow. . . . . 12.0 GPM
Chilled Water Flow . . . . 7.2 GPM
Chilled Water Leaving Temperature. . . . . 45°F

HOT WATER		ENERGY INPUT BTU/H	INLET COND. WATER TEMP.	DELIVERED CAPACITY		REJECTED HEAT BTU/H
INLET TEMP.	OUTLET TEMP.			BTU/H	TONS	
170°F	167.0	16,400	80°F	9,700	0.81	26,100
	167.4	14,500	85°F	6,400	0.53	20,900
	*	*	90°F	*	*	*
175°F	170.7	23,800	80°F	17,300	1.44	41,100
	171.1	21,600	85°F	13,100	1.09	34,700
	*	*	90°F	*	*	*
180°F	174.3	31,200	80°F	24,400	2.03	55,600
	174.8	28,800	85°F	19,400	1.62	48,200
	175.7	23,800	90°F	14,200	1.18	38,000
185°F	178.0	38,400	80°F	31,100	2.59	69,500
	178.5	35,900	85°F	25,600	2.13	61,500
	179.4	30,600	90°F	19,300	1.61	49,900
190°F	181.7	45,800	80°F	36,800	3.07	82,600
	182.2	42,900	85°F	31,300	2.61	74,200
	183.2	37,500	90°F	23,800	1.98	61,300
195°F**	185.3	53,100	80°F	40,600	3.38	93,700
	185.9**	50,000**	85°F**	36,000**	3.00**	86,000**
	186.9	44,300	90°F	27,600	2.30	71,900
200°F	189.3	58,800	80°F	41,800	3.48	100,600
	189.8	56,000	85°F	40,200	3.35	96,200
	190.7	51,000	90°F	30,500	2.54	80,500
205°F	193.4	63,800	80°F	42,000	3.50	105,800
	193.9	60,800	85°F	42,000	3.50	102,800
	194.8	56,200	90°F	32,500	2.71	88,700

*Unit operation unstable in these areas.
**Represents conditions for rated capacity.

PWF 36-100 COOLING MODE



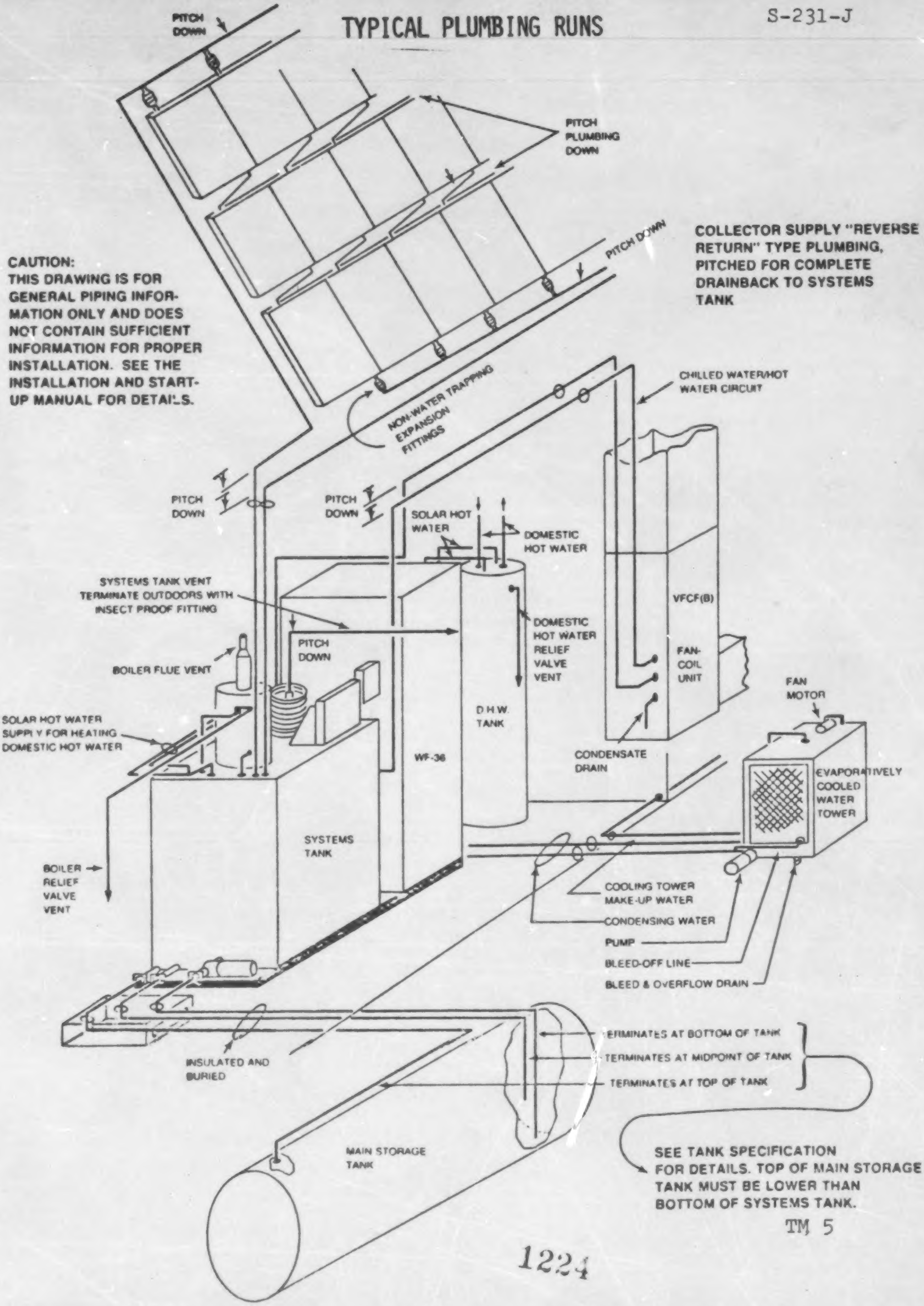
COOLING MODE "ON"
DOMESTIC HOT WATER
HEATER "ON"
COLLECTORS "ON"

TM 4

3-229-J

S-231-J

TYPICAL PLUMBING RUNS

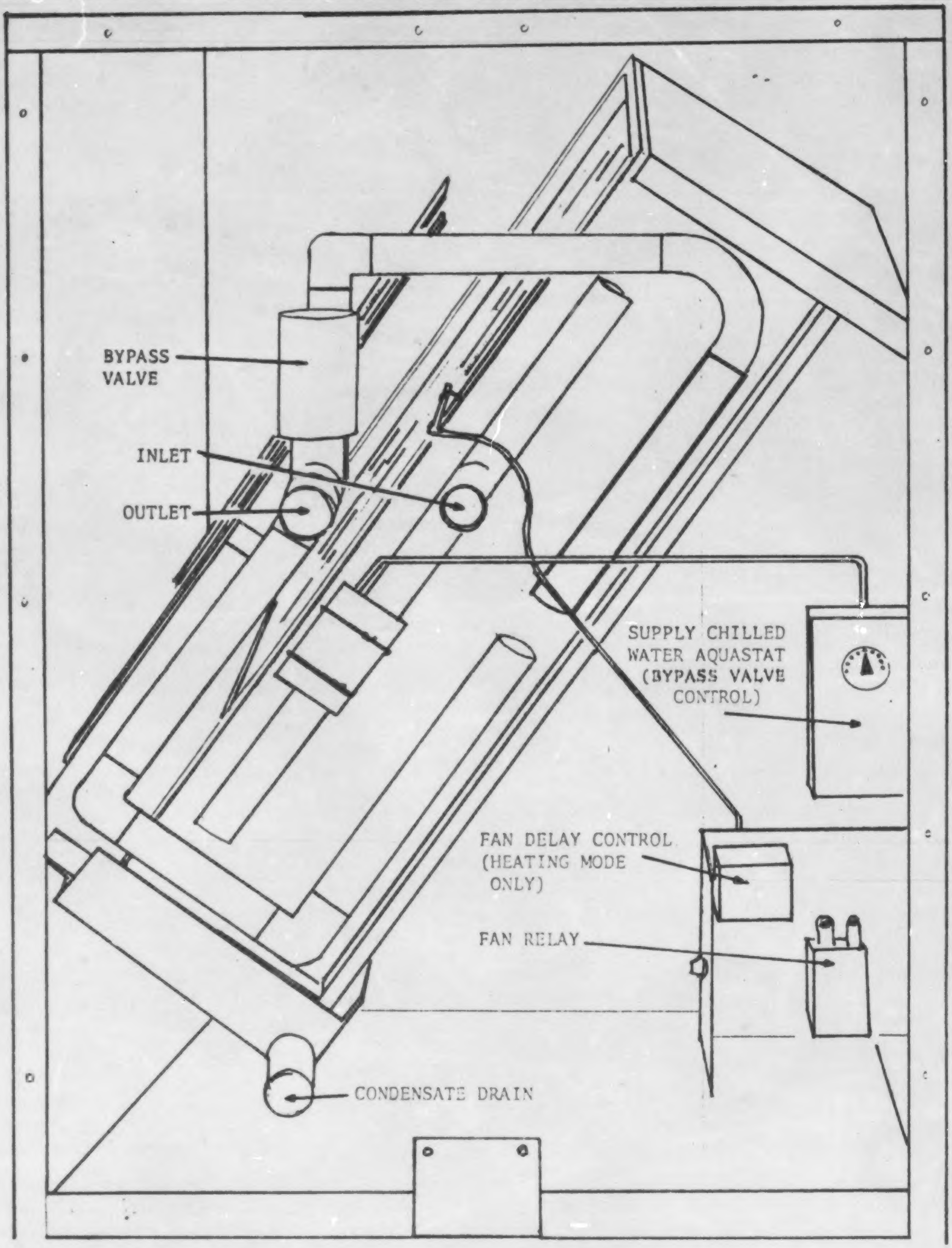

PITCH DOWN
PITCH PLUMBING DOWN
PITCH DOWN
NON-WATER TRAPPING EXPANSION FITTINGS
CHILLED WATER/HOT WATER CIRCUIT
PITCH DOWN
PITCH DOWN
SOLAR HOT WATER
DOMESTIC HOT WATER
SYSTEMS TANK VENT TERMINATE OUTDOORS WITH INSECT PROOF FITTING
PITCH DOWN
DOMESTIC HOT WATER RELIEF VALVE VENT
VFCF(B)
FAN-COIL UNIT
BOILER FLUE VENT
D.H.W. TANK
FAN MOTOR
SOLAR HOT WATER SUPPLY FOR HEATING DOMESTIC HOT WATER
WF-36
CONDENSATE DRAIN
EVAPORATIVELY COOLED WATER TOWER
SYSTEMS TANK
BOILER RELIEF VALVE VENT
COOLING TOWER MAKE-UP WATER
CONDENSING WATER
PUMP
BLEED-OFF LINE
BLEED & OVERFLOW DRAIN
TERMINATES AT BOTTOM OF TANK
TERMINATES AT MIDPOINT OF TANK
TERMINATES AT TOP OF TANK
INSULATED AND BURIED
MAIN STORAGE TANK

CAUTION:
THIS DRAWING IS FOR GENERAL PIPING INFORMATION ONLY AND DOES NOT CONTAIN SUFFICIENT INFORMATION FOR PROPER INSTALLATION. SEE THE INSTALLATION AND START-UP MANUAL FOR DETAILS.

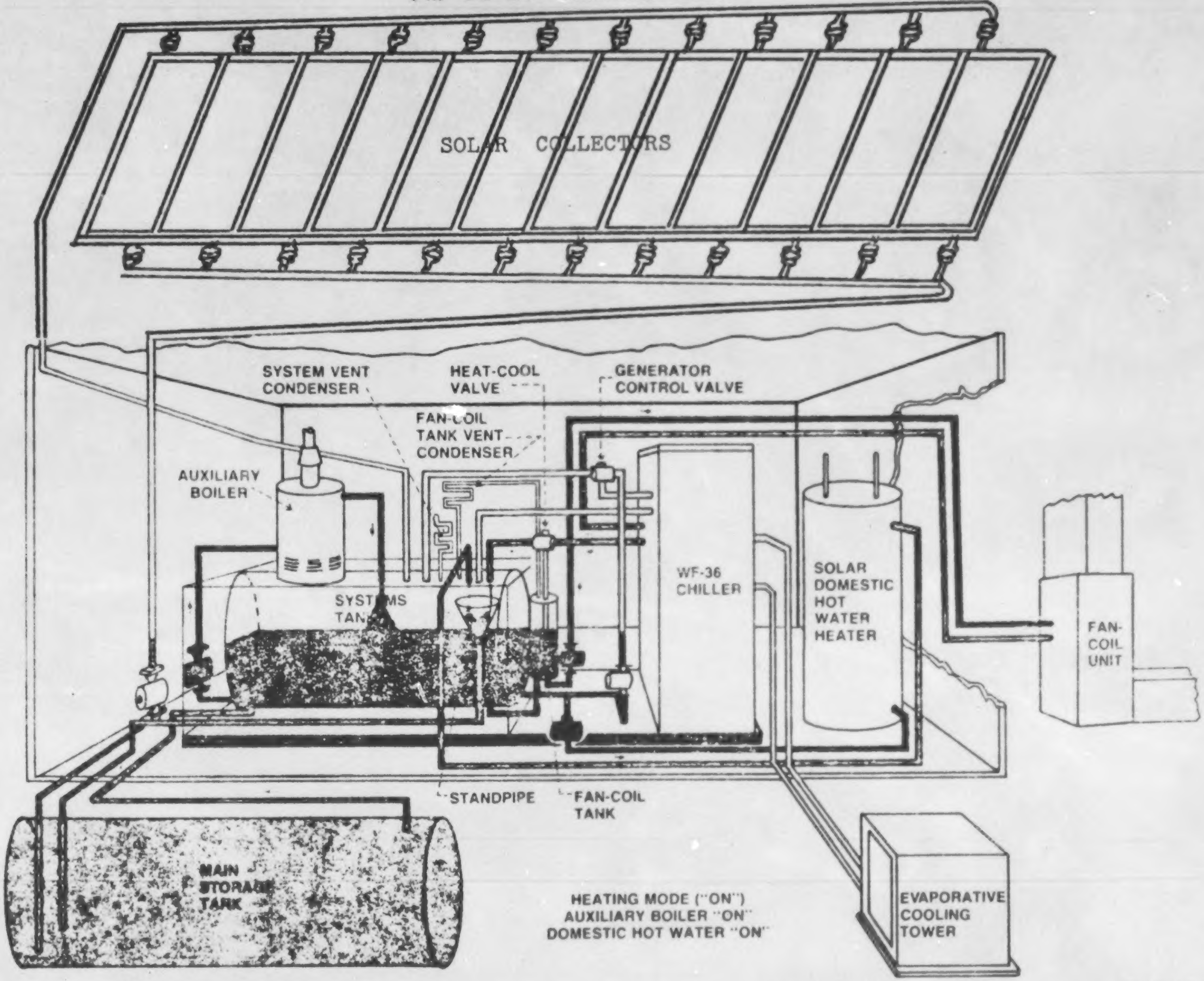
COLLECTOR SUPPLY "REVERSE RETURN" TYPE PLUMBING, PITCHED FOR COMPLETE DRAINBACK TO SYSTEMS TANK

SEE TANK SPECIFICATION FOR DETAILS. TOP OF MAIN STORAGE TANK MUST BE LOWER THAN BOTTOM OF SYSTEMS TANK.

HYDRONIC COIL AND CONTROLS

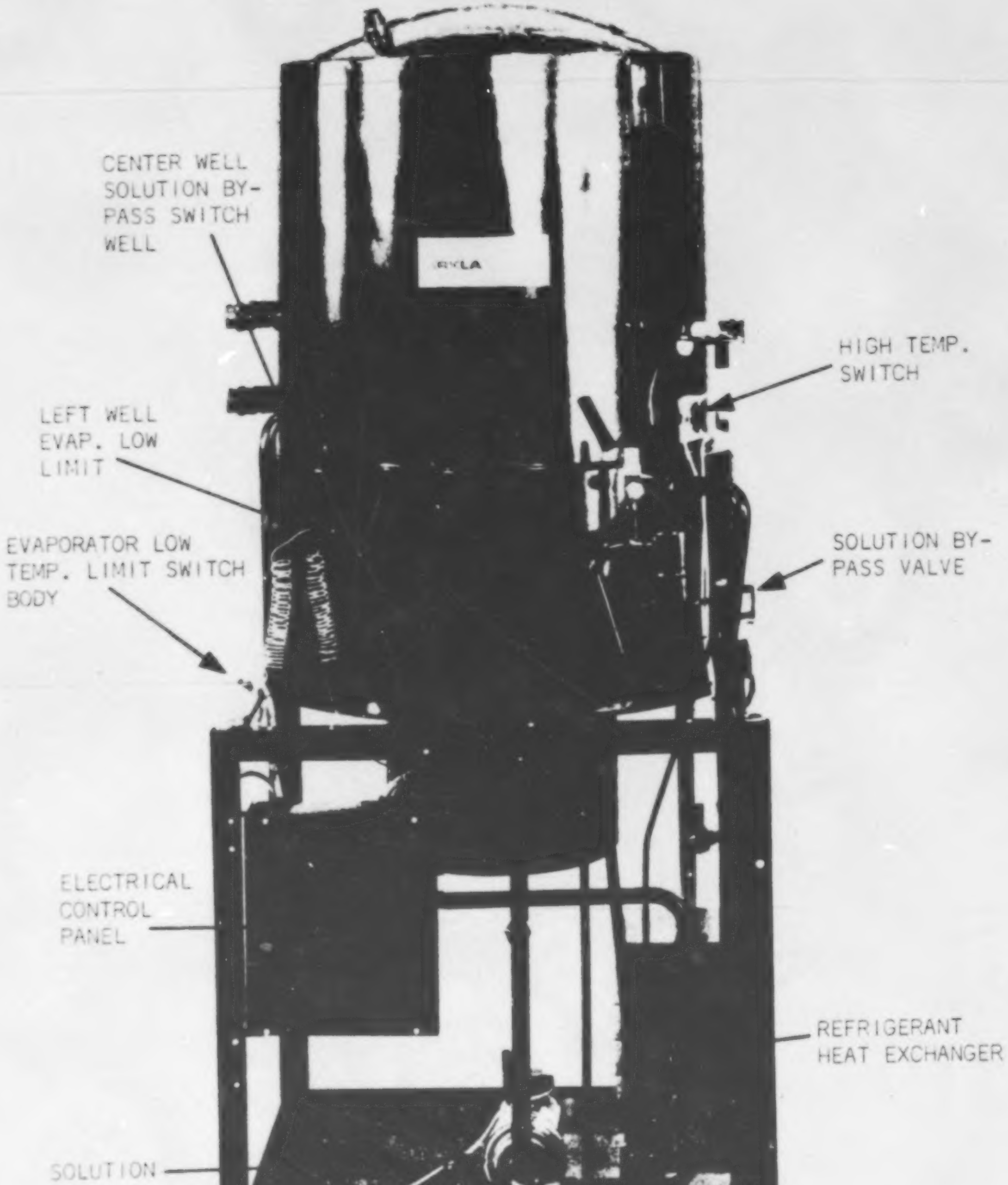

BYPASS VALVE
INLET
OUTLET
SUPPLY CHILLED WATER AQUASTAT (BYPASS VALVE CONTROL)
FAN DELAY CONTROL (HEATING MODE ONLY)
FAN RELAY
CONDENSATE DRAIN

PWF 36-100 HEATING MODE



HEATING MODE ("ON")
AUXILIARY BOILER "ON"
DOMESTIC HOT WATER "ON"

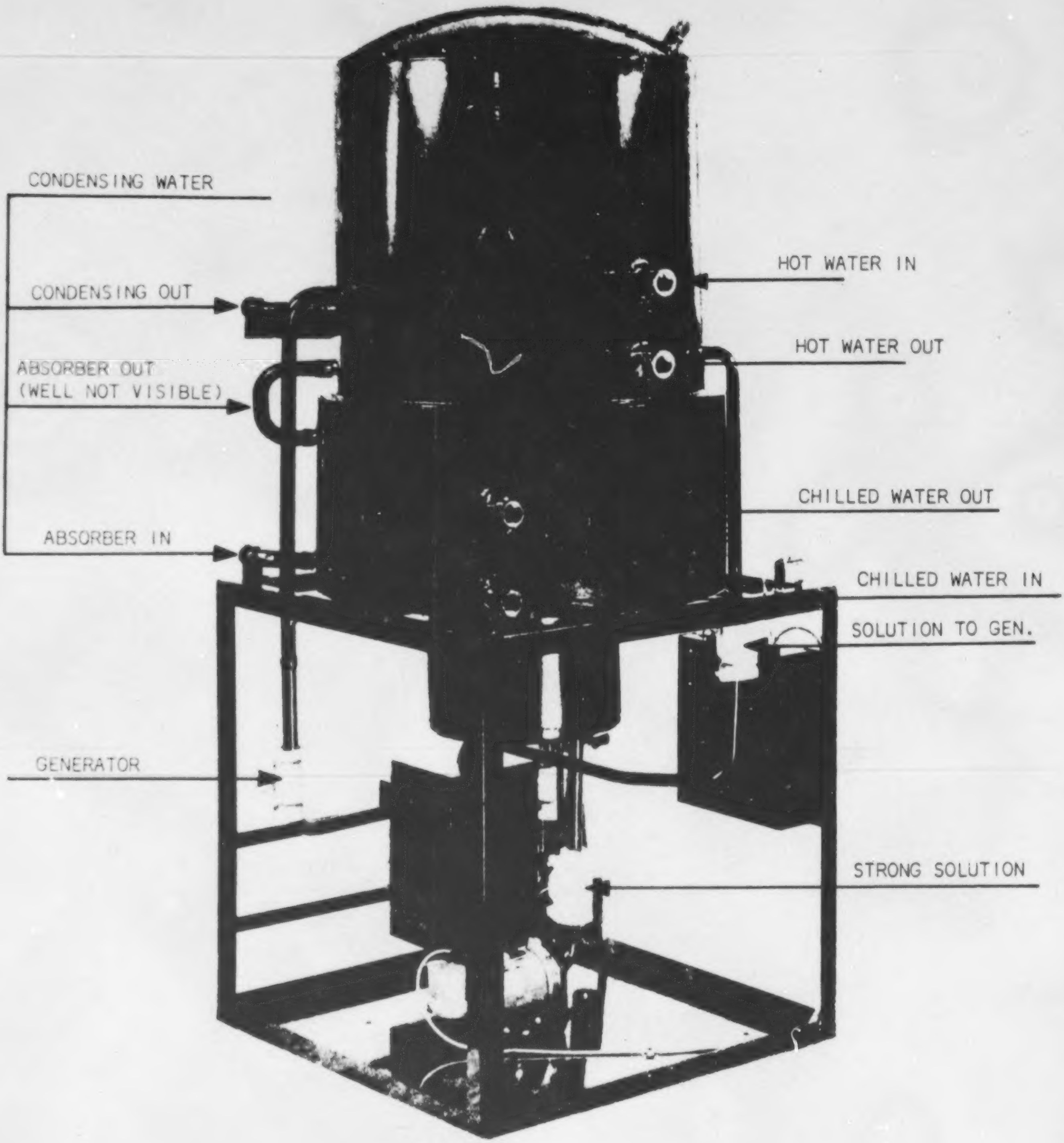
WF-36 SWITCHES AND CONTROLS


CENTER WELL SOLUTION BY-PASS SWITCH WELL
ARKLA
HIGH TEMP. SWITCH
LEFT WELL EVAP. LOW LIMIT
EVAPORATOR LOW TEMP. LIMIT SWITCH BODY
SOLUTION BY-PASS VALVE
ELECTRICAL CONTROL PANEL
REFRIGERANT HEAT EXCHANGER
SOLUTION PUMP

Courtesy of
ARKLA Industries, Inc.

1228

WF-36 THERMOMETER WELL LOCATION



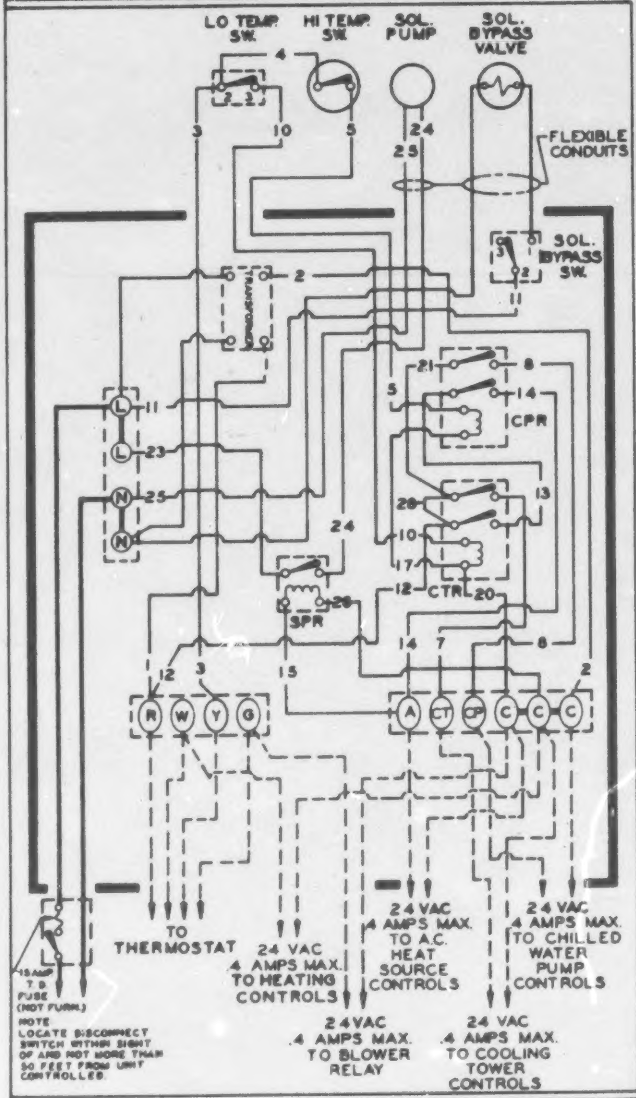
Courtesy of
ARKLA Industries, Inc.

1223

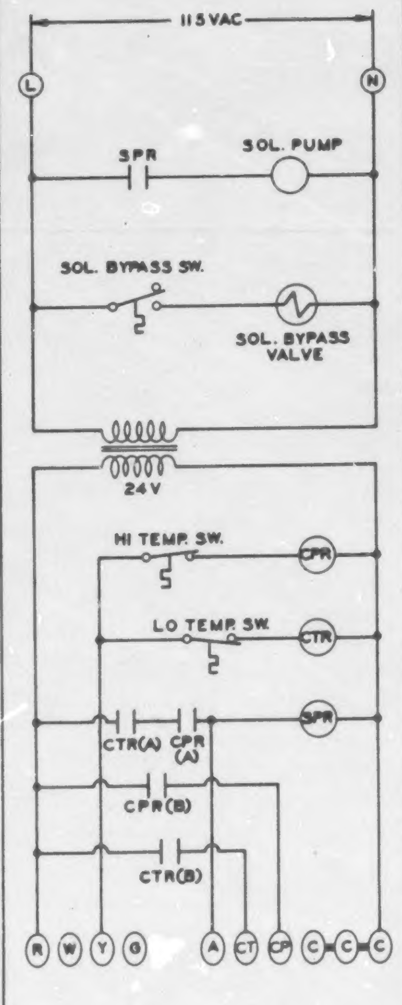
ELECTRICAL CIRCUITS FOR PWF 36-100

NOTES:

1. HEAVY LINES INDICATE CONNECTIONS TO BE MADE AT TIME OF INSTALLATION. MAIN SWITCH AND T.D. FUSE TO BE SUPPLIED LOCALLY.
2. POSITION OF ALL SWITCHES SHOWN WITH POWER OFF.
3. IF ORIGINAL WIRE SUPPLIED IS REPLACED, USE U.L. APPROVED TYPE WIRE FOR 105° C.


LO TEMP. SW.
HI TEMP. SW.
SOL. PUMP
SOL. BYPASS VALVE
FLEXIBLE CONDUITS
SOL. BYPASS SW.
TRANSFORMER
CPR
CTR
SPR
L
L
N
N
R
W
Y
G
A
CT
CP
C
C
C
TO THERMOSTAT
24 VAC .4 AMPS MAX. TO HEATING CONTROLS
24 VAC .4 AMPS MAX. TO A.C. HEAT SOURCE CONTROLS
24 VAC .4 AMPS MAX. TO CHILLED WATER PUMP CONTROLS
24 VAC .4 AMPS MAX. TO BLOWER RELAY
24 VAC .4 AMPS MAX. TO COOLING TOWER CONTROLS
15 AMP T.D. FUSE (NOT FURN.)

NOTE
LOCATE DISCONNECT SWITCH WITHIN SIGHT OF AND NOT MORE THAN 50 FEET FROM UNIT CONTROLLED.



SCHEMATIC DIAGRAM

S-243-J

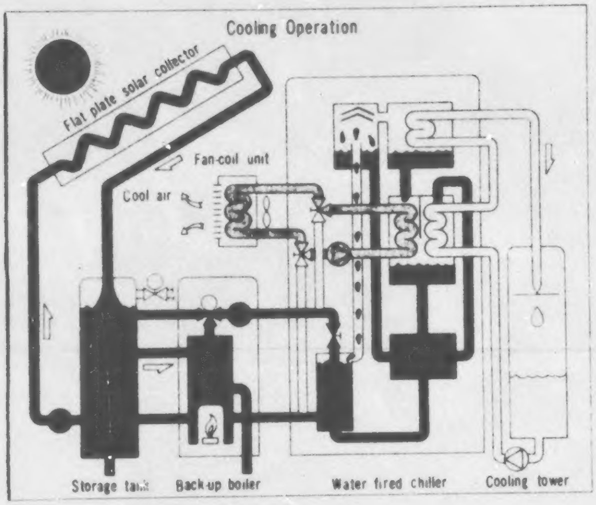
SPECIFICATIONS FOR SOLAIRE WF-36

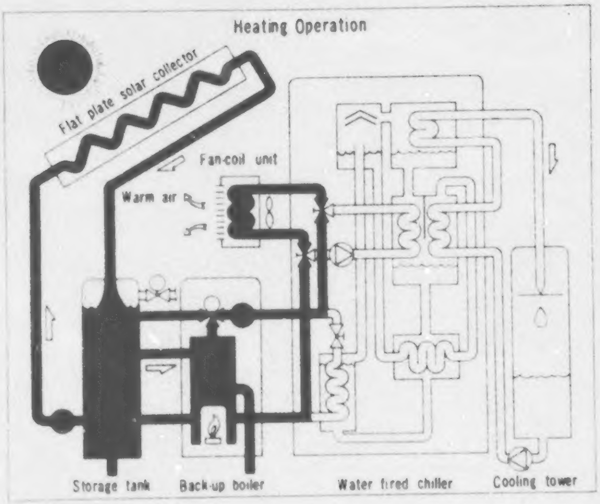
DESIGN DELIVERED CAPACITY, Btu/h.	36,000[1]
DESIGN DELIVERED CAPACITY, Tons I.M.E.	3.0[1]
ENERGY REQUIREMENTS	
Design Hot Water Input, Btu/h	50,000
Design Hot Water Inlet Temperature, °F.	195
Design Hot Water Outlet Temperature, °F	185.9
Permissible Range of Inlet Temp	170 to 205
Design Hot Water Flow, gpm.	11.0
Pressure Drop, Feet of Water, at 11 gpm	9.8
Permissible Range of Flow, gpm.	5 to 22
Pressure Drop, Feet of Water, at 22 gpm	29.9
Maximum Working Pressure, psig.	100
Unit Water Volume, Gallons, Approx.	3.0
Electrical Voltage, 60 Hz, 1 Phase.	115[2]
Maximum Wattage Draw.	250
CHILLED WATER DATA	
Design Inlet Temperature, °F.	55
Design Outlet Temperature, °F	45
Design Flow, gpm.	7.2
Pressure Drop, Feet of Water, at 7.2 gpm	4.6
Permissible Range of Flow, gpm.	4 to 13
Pressure Drop, Feet of Water, at 13 gpm	12.5
Maximum Working Pressure, psig.	100
Unit Water Volume, Gallons, Approx.	1.5
CONDENSING WATER DATA	
Design Heat Rejection, Btu/h.	86,000
Design Inlet Temperature, °F.	85
Design Outlet Temperature, °F	99.3
Permissible Range of Inlet Temp	75 to 90
Design Flow, gpm.	12.0
Pressure Drop, Feet of Water, at 12 gpm	9.6
Permissible Range of Flow, gpm.	9 to 25
Pressure Drop, Feet of Water, at 25 gpm	33.9
Maximum Working Pressure, psig.	100
Unit Water Volume, Gallons, Approx.	3.0
COOLING TOWER SELECTION DATA	
Maximum Heat Rejection, Btu/h	106,000
Range, °F	14 to 17
Minimum Permissible Sump Temperature, °F.	75[3]
SERVICE CONNECTIONS	
Hot Water Inlet and Outlet.	1" FPT
Chilled Water Inlet and Outlet.	1" FPT
Condensing Water Inlet and Outlet	1" FPT
PHYSICAL DATA, APPROXIMATES	
Operating Weight, Pounds.	675[4]
Shipping Weight, Pounds	680[5]
Crated Size, Inches	36W, 34D, 75H

TM 11

S-245-J

YAZAKI SOLAR ABSORPTION SYSTEM



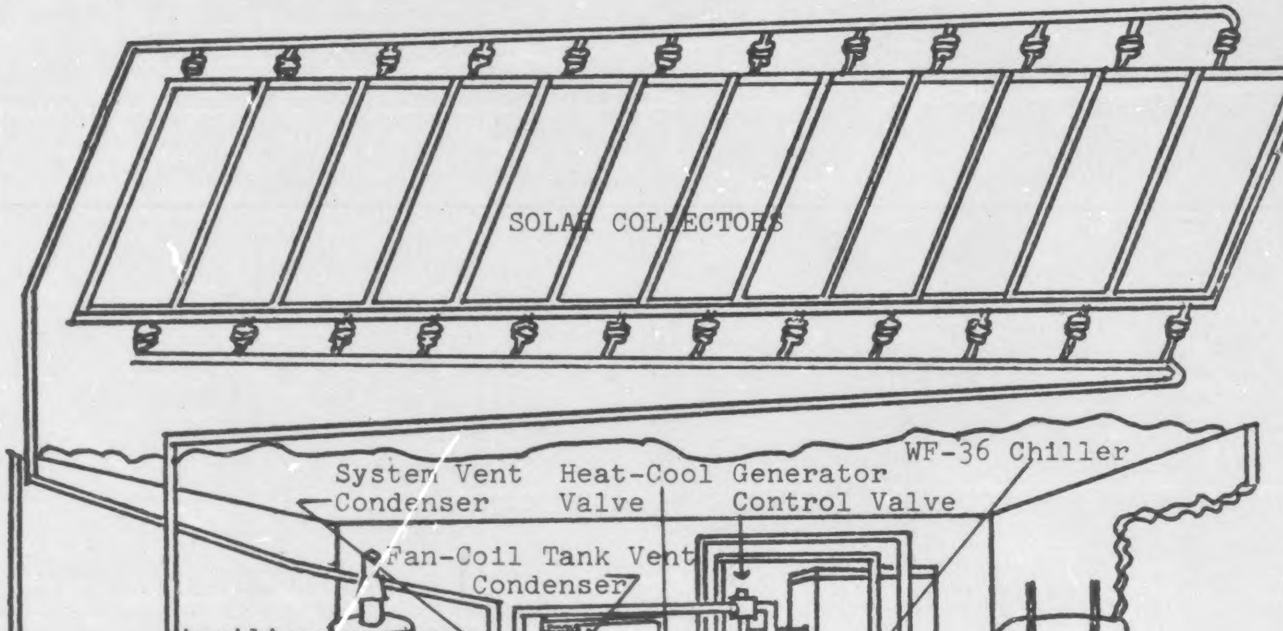


Courtesy of
YAZAKI Corporation

SOLAR ABSORPTION SYSTEMS
UNIT III

ASSIGNMENT SHEET #1--IDENTIFY PIPING RUNS USED IN A SOLAR FIRED ABSORPTION HEAT/COOL SYSTEM IN THE COOLING MODE

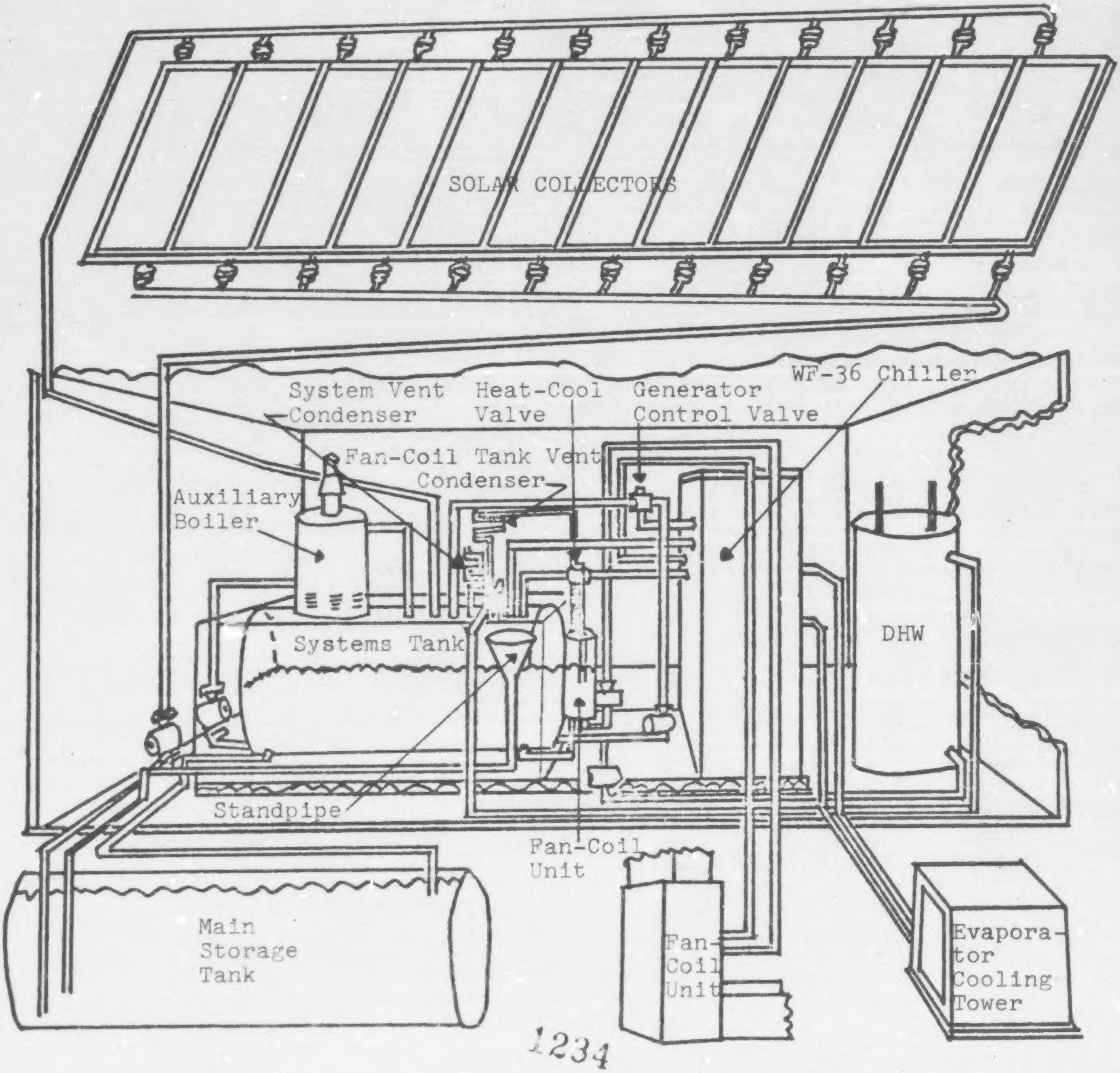
Directions: Use a lead pencil to darken the piping circuits used in the cooling mode in the solar system below.



SOLAR ABSORPTION SYSTEMS

ASSIGNMENT SHEET #2--IDENTIFY PIPING CIRCUITS AND COMPONENTS USED IN THE HEATING MODE OF A SOLAR FIRED ABSORPTION HEAT/COOL SYSTEM

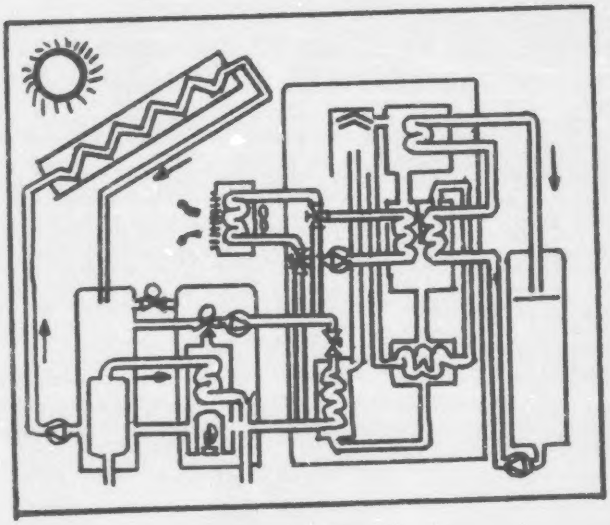
Directions: Use a lead pencil to darken the piping circuits and components used in the solar heating mode of the absorption system below.



SOLAR ABSORPTION SYSTEMS

ASSIGNMENT SHEET #3--IDENTIFY PIPING CIRCUITS AND COMPONENTS USED IN THE COOLING MODE OF AN ABSORPTION HEAT/COOL SYSTEM WITH AUXILIARY BOILER "ON"

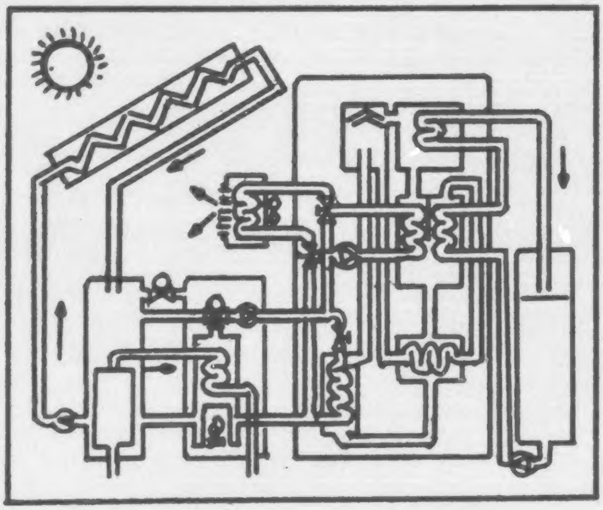
Directions: Use a lead pencil to darken each piping circuit and component used in the cooling mode in the system below.



SOLAR ABSORPTION SYSTEMS

ASSIGNMENT SHEET #4--IDENTIFY PIPING CIRCUITS INVOLVED IN THE SOLAR HEAT MODE OF AN ABSORPTION HEAT/COOL SYSTEM WITH BACK-UP BOILER "OFF"

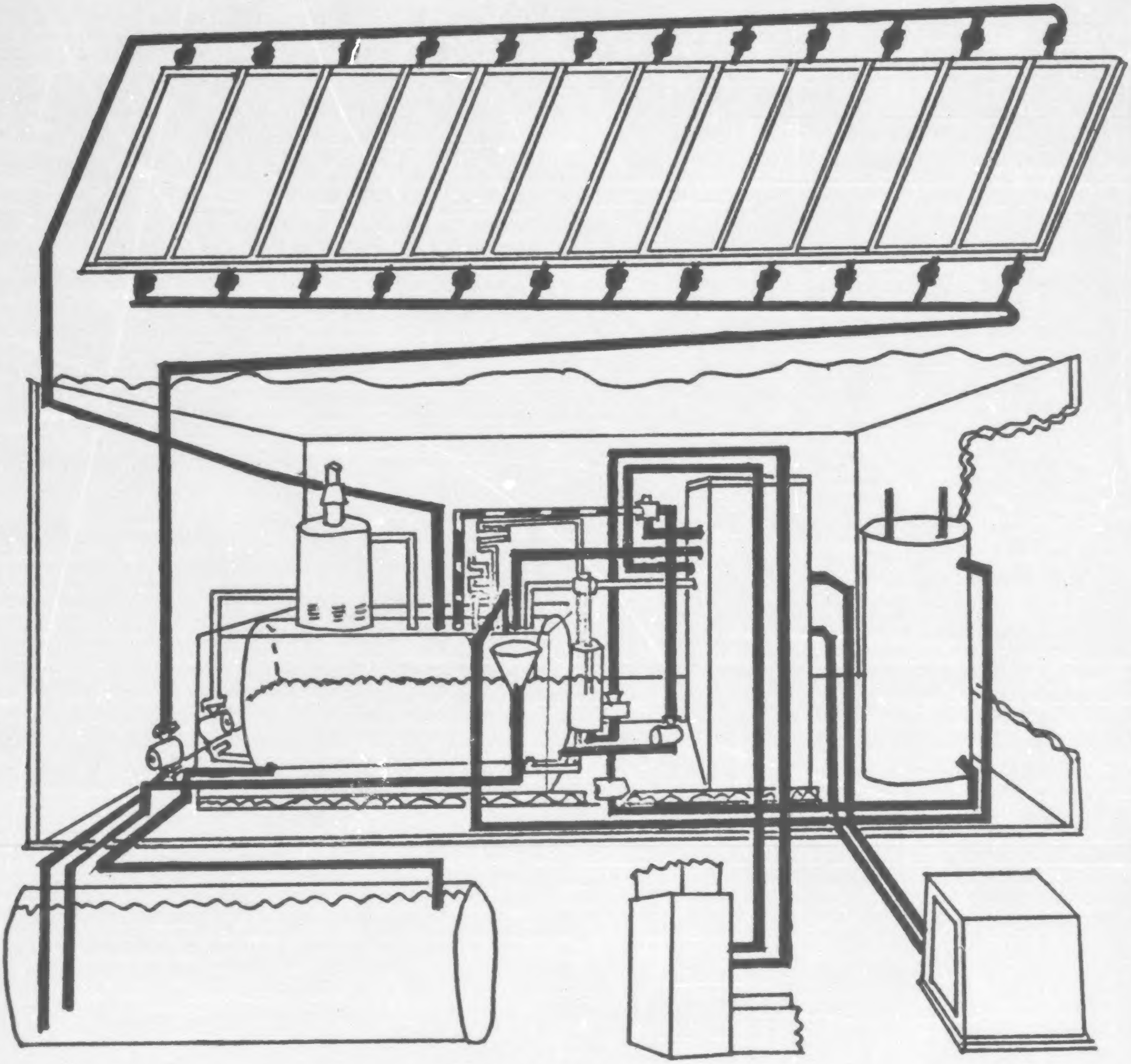
Directions: Use a lead pencil to darken each piping circuit involved in the solar heat mode of the absorption system below.



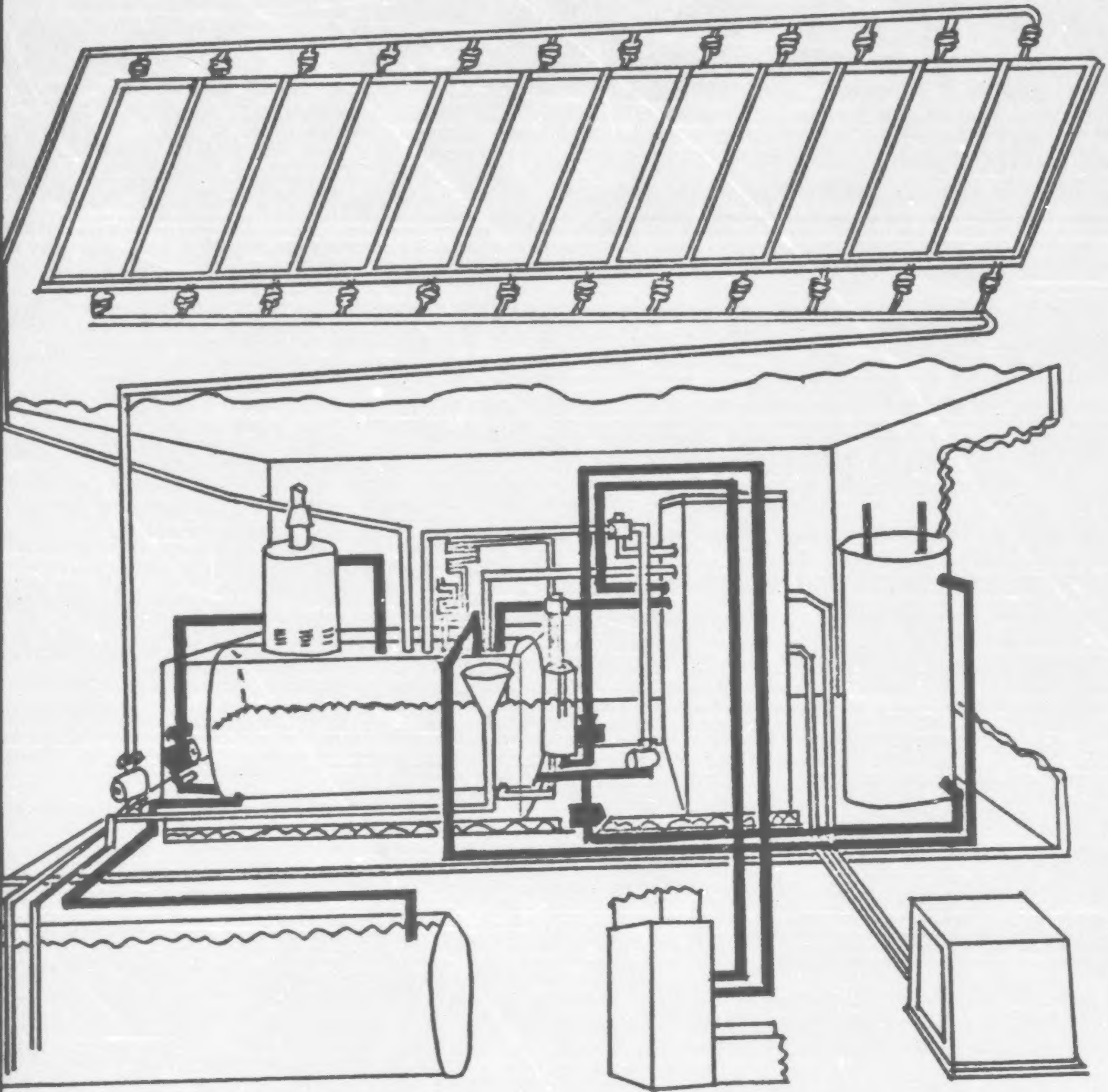
SOLAR ABSORPTION SYSTEMS
UNIT III

ANSWERS TO ASSGINMENT SHEETS

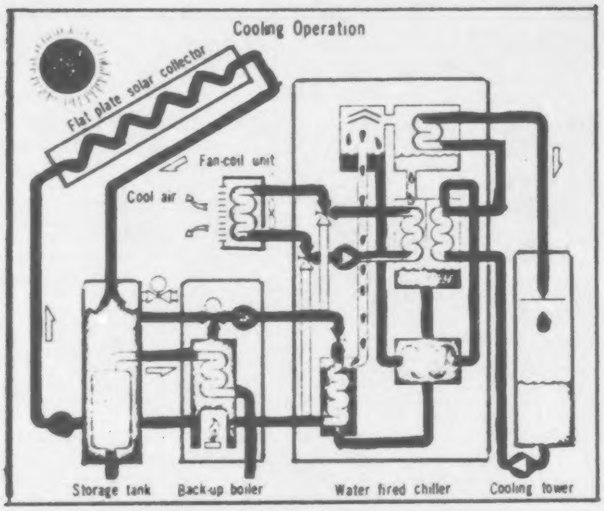
Assignment Sheet #1



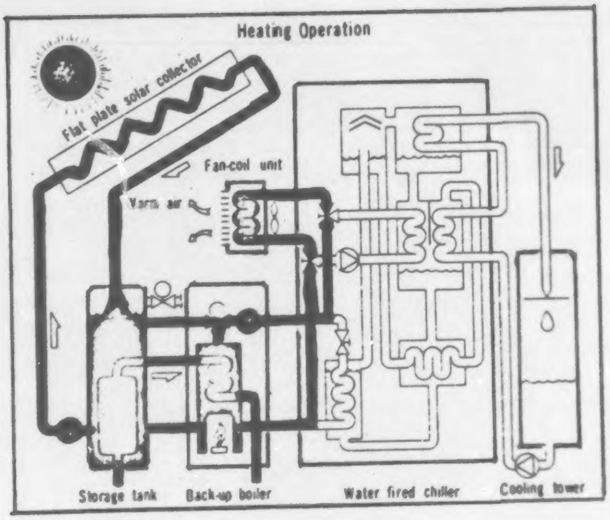
Assignment Sheet #2



Assignment Sheet #3



Assignment Sheet #4



SOLAR ABSORPTION SYSTEMS
UNIT III

JOB SHEET #1--ASSEMBLE A PWF 36-100 PACKAGE UNIT AND LOCATE SUPPORT COMPONENTS

I. Tools, components and equipment

  A. Storage tank

  B. Standard hand tools

  C. Equipment required to move and locate components

  D. PWF 36-100 package unit

  E. Fan-coil unit

  F. Evaporation cooling tower

  G. Required number of collectors

  H. Level

  I. Hardware needed to install collectors

II. Procedures

  A. Locate the PWF 36-100 package unit at selected location

  B. Level unit

  C. Locate the cooling tower at selected location

  D. Locate the fan-coil unit at selected location

  E. Locate the storage tank

  F. Assemble the required mounting hardware for installation of collector plates

  G. Assemble the required number of collectors

  H. Have your instructor check and evaluate placement and location of package unit and support components

  Date______________ By ____________________________

  I. Clean up area and return tools to storage

SOLAR ABSORPTION SYSTEMS

JOB SHEET #2--INSTALL PIPING CIRCUITS FOR AN ABSORPTION HEAT/COOL PACKAGE SYSTEM WITH DRAIN BACK COLLECTOR LOOP

I. Tools, materials and supplies

- A. Basic hand tools
- B. Special tools and equipment
- C. Required amount of copper pipe
- D. Torch outfit
- E. Solder
- F. Flux
- G. Required amount of pipe insulation
- H. Required assortment of copper fittings
- I. Required assortment of valves
- J. Required assortment of hardware and supplies
- K. Copy of manufacturers installation manual
- L. Required number of selected collector plates
- M. Expansion joints or silicone hose
- N. Required collector mounting racks
- O. Collector pump (if not part of package unit)
- P. Absorption system located at selected site

II. Procedures

- A. Study the manufacturers installation manual on proper collector loop installation procedures
- B. Complete an outlined drawing of proposed installation methods to include: location of pipes, supports, drain back pitch of piping, location of valves and circulator pumps

C. Complete an outlined drawing of proposed installation methods for the collectors to include:

1. Location of collectors

2. Type and location of collector supports

3. Methods of connecting collectors to piping manifolds

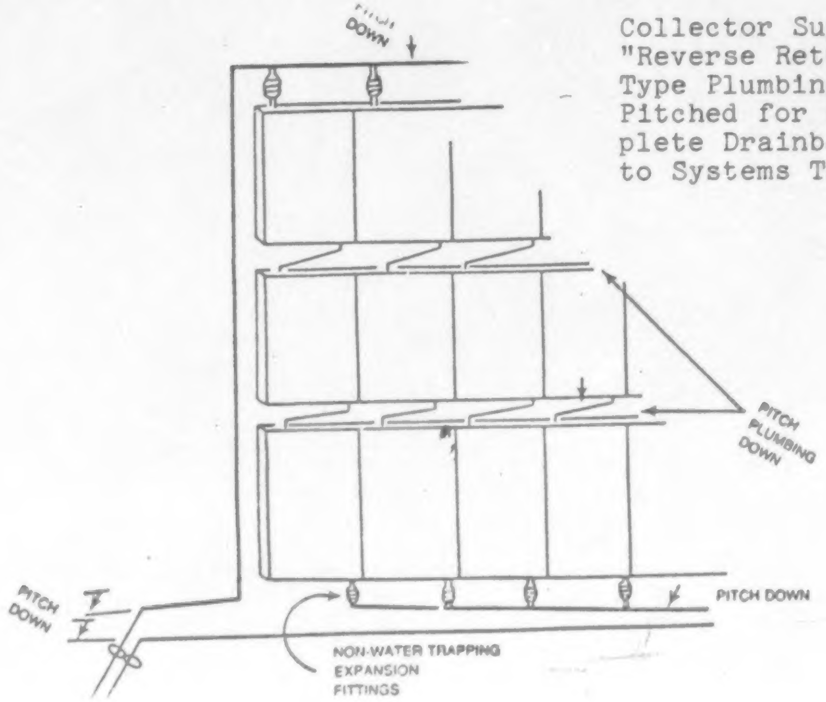
D. Have your instructor evaluate and approve the installation outlines

Date_______________ By_______________________________

E. Assemble the required mounting racks

F. Assemble the required hardware

G. Install the mounting racks and collectors with drain back pitch (Figure 1)



Collector Supply "Reverse Return" Type Plumbing, Pitched for Complete Drainback to Systems Tank

FIGURE 1

H. Have the instructor evaluate the installation

Date______________ By___________________________

I. Install the piping, valves, pipe insulation and supports in the collector loop

J. Connect the collector supply line to the collector pump

K. Have the instructor evaluate the installation

Date______________ By___________________________

L. Clean up the area and return tools and equipment to storage

SOLAR ABSORPTION SYSTEMS

JOB SHEET #3--INSTALL PIPING CIRCUITS FOR AN ABSORPTION HEAT/COOL SYSTEM STORAGE TANK

I. Tools, materials and supplies

  A. Basic hand tools

  B. Special tools and equipment

  C. Torch outfit

  D. Solder and flux

  E. Required amount of copper pipe

  F. Required amount of pipe insulation

  G. Required number of copper fittings

  H. Required number of valves

  I. Required assortment of hardware and materials

  J. Copy of manufacturers installation manual

  K. Miscellaneous supplies

  L. Circulator pump (if not part of a package unit)

  M. Storage tank

II. Procedures

  A. Study the manufacturers installation manual on proper storage tank installation procedures

  B. Locate the storage tank at selected location

  C. Complete an oultined drawing of proposed installation methods to include: location of pipes, supports, pitch of pipes, pump and valves

  D. Have your instructor evaluate your outline

  Date______________ By____________________________

  E. Assemble the required materials, supplies and hardware

F. Install the storage tank using approved methods

G. Install the piping circuit, pipe insulation and any valves required between the storage tank and collector pump

H. Install the piping circuits, pipe insulation and required valves between the storage tank and systems tank

I. Install circulator pump (if not part of a package unit)

J. Have the instructor evaluate the installation

Date______________ By___________________________

K. Clean up the area and return all tools and equipment to storage

SOLAR ABSORPTION SYSTEMS

JOB SHEET #4--INSTALL AN EVAPORATIVE COOLING TOWER FOR AN ABSORPTION HEAT/COOL SYSTEM

I. Tools and materials

   A. Basic hand tools

   B. Special tools and equipment

   C. Torch outfit

   D. Solder and flux

   E. Required amount of copper pipe

   F. Required amount of pipe insulation

   G. Required number of copper fittings

   H. Required number of valves

   I. Required assortment of materials

   J. Required assortment of hardware

   K. Manufacturers installation manual

   L. Cooling tower circulator pump (if not part of a package unit)

   M. Cooling tower

   N. Makeup water line valve

II. Procedures

   A. Study the manufacturers installation manual on tower installation procedures

   B. Locate the cooling tower at selected site

   C. Complete an outlined drawing of proposed installation methods to include:

      1. Location of pumps and valves

      2. Piping location

      3. Location of pipe supports

D. Complete an itemized list of all materials and supplies that will be required including:

   1. Pipe and pipe insulation

      a. Type, size and amount

   2. Supports

      a. Type, size and amount

   3. Screws and bolts

      a. Type, size and amount

E. Have the instructor evaluate the outline and materials list

   Date______________ By____________________________

F. Install the pipe, valves and pipe insulation

G. Install the cooling tower pump (if required)

H. Install the cooling tower makeup water circuit

I. Install any bleed-off or overflow circuits required

J. Have the instructor evaluate the installation

   Date______________ By____________________________

K. Clean up the area and return all tools and equipment to storage

SOLAR ABSORPTION SYSTEMS

JOB SHEET #5--INSTALL A FAN-COIL UNIT FOR A SOLAR ABSORPTION HEAT/COOL SYSTEM

I. Tools and materials

   A. Basic hand tools

   B. Special tools and equipment

   C. Torch outfit

   D. Solder and flux

   E. Required amount of copper pipe

   F. Required amount of pipe insulation

   G. Required number of copper fittings

   H. Required number of valves

   I. Circulator pump (if not part of package unit)

   J. Required amount of hardware and materials

   K. Copy of manufacturers installation manual

   L. Miscellaneous supplies

   M. Fan-coil unit

II. Procedures

   A. Study the manufacturers installation manual on proper fan-coil unit installation procedures

   B. Locate the fan-coil unit at selected site

   C. Complete an outlined drawing of proposed installation methods to include:

      1. Location of pipes and hardware

      2. Location of pump and valves

   D. Complete a materials and supplies list to include:

      1. Type, size and amount of copper pipe

2. Type, size and amount of pipe insulation
3. Type, size and number of valves
4. Type, size and amount of miscellaneous supply items (screws, bolts, etc.)
5. Type, size and amount of hardware items (braces, supports, etc.)

E. Have the instructor evaluate your outline and materials list

Date______________ By____________________________

F. Assemble the needed tools and materials

G. Install any needed braces and supports for piping

H. Install the fan-coil unit circulator pump (if required)

I. Install the piping circuits, valves and pipe insulation

J. Have the instructor evaluate the installation

Date______________ By____________________________

K. Clean up the area and return all tools and equipment to storage

SOLAR ABSORPTION SYSTEMS

JOB SHEET #6--INSTALL GAS PIPING CIRCUIT FOR THE BACK-UP BOILER OF AN ABSORPTION HEAT/COOL SYSTEM

I. Tools and materials

- A. Standard hand tools
- B. Special tools and equipment
- C. Required amount of black pipe
- D. Required number of pipe fittings
- E. Required number of valves
- G. Required amount of hardware and materials
- H. Required vent pipe, flashing, pipe joints and cap
- I. Miscellaneous supplies
- J. Back-up boiler (may be part of a package unit)
- K. Manufacturers installation manual
- L. Air gauge for leak testing
- M. Air tank
- N. Required amount of copper pipe for boiler relief valve vent
- O. Required number of copper fittings

II. Procedures

- A. Study the manufacturers installation manual on boiler installation procedures
- B. Locate the boiler at selected site
- C. Complete an outline drawing of proposed installation methods to include:
  1. Location of pipes
  2. Location of valves and fittings
  3. Location of supports and hardware

D. Complete a material and supply list to include:

   1. Type, size and amount of piping

   2. Type, size and number of pipe fittings

   3. Type, size and number of valves

   4. Type, size and amount of hardware (supports, racks, etc.)

   5. Type, size and amount of miscellaneous supplies to include:

      a. Screws, nuts and bolts

      b. Screw anchors, etc.

      c. Pipe dope

E. Have the instructor evaluate the outline and materials list

Date______________ By____________________________

F. Assemble needed tools and equipment

G. Assemble needed materials and supplies

H. Install the gas pipe and valves

(CAUTION: Do not turn on the gas until instructed to do so by your instructor.)

I. Install the air pressure gauge

J. Pressurize the piping circuit with air

K. Have your instructor evaluate the installation

Date______________ By____________________________

L. Correct any leaks and retest

M. Remove the air pressure gauge

N. Install the boiler pressure relief valve vent piping

O. Install the boiler flue vent, flashing and cap

P. Have the instructor evaluate the installation

Date______________ By____________________________

Q. Clean up the area and return all tools and equipment to storage

SOLAR ABSORPTION SYSTEMS

JOB SHEET #7--INSTALL SOLAR HOTWATER HEATER PIPING CIRCUIT

I. Tools and materials

A. Basic hand tools

B. Torch outfit

C. Solder and flux

D. Required amount of copper pipe

E. Required amount of copper fittings

F. Required amount of pipe insulation

G. Required number of valves

H. Temperature mixing valve

I. Manufacturers installation manual

J. Domestic hotwater heater

K. Domestic hotwater heater circulator pump

II. Procedures

A. Study the manufacturers installation manual

B. Locate the DHW heater at selected site

C. Complete an outline of the piping circuit

D. Complete a list of all materials and supplies needed to install the hotwater heater

E. Have the instructor evaluate the outline and materials and supply list

Date______________ By___________________________

F. Assemble all materials and supplies

G. Install the cold water supply piping circuit

H. Install the hotwater piping circuit

I. Install the temperature mixing valve and any required check valve

J. Install the heat exchanger piping circuit

K. Install the DHW heater circulator pump

L. Have the instructor evaluate the installation

Date______________ By____________________________

M. Drain the DHW heater tank

N. Clean up the area and return all tools and equipment to storage

SOLAR ABSORPTION SYSTEMS

JOB SHEET #8--INSTALL POWER AND CONTROL CIRCUITS FOR A SOLAR ABSORPTION HEAT/COOL SYSTEM

I. Tools and materials

  A. Basic hand tools

  B. Special tools and equipment

  C. Room thermostat

  D. Power wiring materials

  E. Control wiring materials

  F. Differential thermostats for

    1. Control of solar collector pump operation

    2. Control of solar domestic hotwater pump operation

  G. Sensors for differential thermostats

  H. Sensor wiring materials

  I. Copy of manufacturers installation manual

II. Procedures

  A. Study the manufacturers manual on procedures for installation of power, control and sensor wiring

  B. Complete a wiring diagram of the power wiring circuits for the following

    1. Differential thermostats

    2. Collector pump

    3. Cooling tower pump

    4. Back-up boiler pump

    5. Cooling tower fan motor

    6. Fan-coil unit blower motor

    7. Branch circuit wiring from power panel to absorption system disconnects

C. Complete a wiring diagram of the low voltage and sensor wiring circuits to include:

   1. Room thermostat

      a. Field installed wiring

      b. System wiring to:

         1) Heat circuit relays, controls and valves

         2) Cool circuit relays, controls and valves

D. Complete a materials and supplies list to include:

   1. Type, size and amount of power wiring materials

   2. Type, size and number of disconnect switches

   3. Type, size and number of circuit breakers needed

   4. Type, size and number of circuit fuses needed

   5. Type, size and amount of low voltage wiring materials

   6. Miscellaneous hardware and supplies needed

E. Have the instructor evaluate the diagrams and material list

   Date______________ By ____________________________

F. Assemble the needed tools and materials

G. Install the power wiring circuits

H. Install the low voltage circuits

I. Install the sensor circuits

   (CAUTION: Do not apply power to the circuits until instructed to do so by your instructor.)

J. Have the instructor evaluate the installation

   Date______________ By ____________________________

K. Clean up the area and return all tools and equipment to storage.

SOLAR ABSORPTION SYSTEMS

JOB SHEET #9--START-UP AND CHECK PERFORMANCE OF AN ABSORPTION HEAT/COOL SYSTEM

I. Tools and materials

A. Basic hand tools

B. Temperature testers

C. Volt-amp meter

D. Air manometer

E. Water manometer

F. Copy of manufacturers start-up and check manual

G. Water fill hose

II. Procedures

A. Study manufacturers start-up and check procedures

B. Fill the domestic hotwater heater

C. Fill the storage tank according to manual instructions and check for leaks

D. Fill the systems tank according to manual instructions and check for leaks

E. Fill the cooling tower according to manual instructions and leak check

F. Set the room thermostat system switch to "off"

G. Turn on the power supply to the absorption system

H. Turn the collector loop differential thermostat to manual operation and fill the collector loop

I. Check the collector piping circuit for leaks

J. Turn the collector differential thermostat to "automatic" control

K. Turn the room thermostat system switch to "cool" and the fan switch to "automatic"

L. Check operation of the auxiliary boiler

M. Check and adjust the gas pressure to boiler burner using the water manometer according to manufacturers recommendations

N. Have the instructor evaluate your performance

Date______________ By___________________________

O. Check operation of the system in the cooling phase following recommended procedures to test operation of different components in the cooling phase

P. Check operation of the system in the heating phase, follow recommended procedures to test different components in the system

Q. Complete the start-up and check out forms provided in the manufacturers manual

R. Have the instructor evaluate your performance, methods and collected data

Date______________ By___________________________

S. Check operation of the domestic hotwater heater circuit

T. Check air flow across the fan-coil unit

U. Have the instructor evaluate your progress

Date______________ By___________________________

V. Turn off all power, water and gas to the system

W. Set all switches and thermostats to the "off" position

X. Clean up the areas and return all tools and equipment to storage

Y. Turn in all data sheets to the instructor

SOLAR ABSORPTION SYSTEMS
UNIT III

NAME________________________

TEST

1. Match the terms on the left to their correct definitions or descriptions.

_____a. Change of state

_____b. Evacuated tube collector

_____c. Coefficient of performance (COP)

_____d. Concentrating collector

_____e. Absorbent

_____f. Ton of refrigeration

_____g. Thermosiphoning

_____h. Refrigerant

_____i. Linear concentrating collector

1. Ratio of heat removal rate to heat supply rate
2. A type of concentrating collector, oblong in shape, which focuses the reflected radiation onto a tube absorber
3. The principle that heated gases and liquids rise naturally
4. Heat removal at a rate of 12,000 Btu's per hour
5. The physical form of matter changes from solid to liquid
6. Working fluid in a refrigeration system
7. A class of collectors that use reflector surface to focus solar radiation on a small area
8. Collector with a vacuum surrounding the absorber to reduce losses by conduction and convection

9. A liquid which combines chemically with a refrigerant

2. List two manufacturers of solar absorption chillers for domestic air conditioning systems.

   a. ____

   b. ____

3. List the type of refrigerant and absorption solution used with solar absorption chillers

   a. Refrigerant--__________________________________

   b. Absorption solution--__________________________

4. Match components on the left to their correct function on a Solaire PWF 36-100 system.

   _____a. Control panel

   _____b. Generator input control valve

   _____c. Circuit breakers

   _____d. Systems tank

   _____e. Relief valve

   _____f. Chiller

   _____g. Boiler gas valve

   _____h. Generator pump

   _____i. Flow switch

   _____j. Burner modulation control

   _____k. Boiler Hi-limit control

   _____l. Boiler exhaust vent

   1. Provides a drain-back reservoir for fluids in the various circuits

   2. Contains the condenser, evaporator, solution control chamber and absorber

   3. Provide on site interruption of power to the system and protection to individual load circuits

   4. Allows the gas valve to open after water flow through the boiler has been established

   5. Controlled by the generator control relay during the cooling mode

_____m. Auxiliary boiler

_____n. System vent

_____o. Fan coil pump

_____p. Collector pump

_____q. Auxiliary boiler pump

_____r. Domestic hotwater heater pump

_____s. Systems tank water level gauge

6. Provides means of exhausting gas fumes to the outside

7. Provides unit operating and safety controls, power and connection points for system operating relays

8. Provides a source of heat to supplement solar heat or provide total heat for the heating or cooling mode

9. Controls burner operation in both heating and cooling modes if the boiler outlet temperature reaches 200°F

10. Varies gas input to the burner to provide desired output

11. Solenoid controlled valve that serves as a shut off valve when the boiler is not needed

12. Provides the absorption chiller with hot water from the systems tank

13. Pressure/temperature relief valve to prevent possible overheating of water in the boiler

14. Provides circulation of chilled or heated water through the fan coil unit

15. Circulates hot water from systems tank through heat exchanger in the DHW heater

16. Circulates water from the systems tank to the boiler and back to the systems tank

17. Provides venting of air from the systems tank to outdoors

18. Indicates level of water in the systems tank

5. List two requirements to be considered in selection of collectors for a solar absorption system.

a. ______________________________

____

____

b. ______________________________

____

6. Select required performance dats for the WF-36 chiller by placing an "X in the appropriate blanks.

_____a. Hot water flow

_____b. Evaporator fan speed

_____c. Condensing water flow

_____d. Chilled water flow

_____e. Collector drain back rate

_____f. Pumping rate of sump circulator

_____g. Chilled water entering temperature

_____h. Chilled water leaving temperature

7. Match the components on the left to their correct funtion in the PWF 36-100 cooling mode.

_____a. Solar collectors

_____b. Chiller

_____c. Fan-coil tank

_____d. Systems tank

_____e. Fan-coil tank unit condenser

_____f. System vent condenser

_____g. Evaporative cooling tower

_____h. Fan-coil unit

_____i. Solar domestic hotwater heater

_____j. Heat-cool valve

_____k. Cooling tower pump

_____l. Auxiliary boiler

_____m. Main storage tank

_____n. Generator pump

_____o. Collector pump

_____p. Domestic hotwater heater pump

_____q. Generator control valve

1. Condenses any hot vapor attempting to migrate to the chilled water in the fan coil tank

2. Condenses hot vapors which otherwise would escape to the atmosphere

3. Converts solar radiation into solar heat

4. Provides a drain back reservoir for liquids in the various piping circuits

5. Provides chilled water to cool air from the conditioned space

6. Small volume tank serving as an air separation chamber for recirculating chilled water in the cooling mode

7. Designed to reject the full output of the absorption chiller at maximum design conditions

8. Hydronic coil equipped with a motorized 2-position diverter valve and blower

9. Circulates hot water from the systems tank to the chiller unit generator

10. Provides hot water for home use

11. Sized to provide percentage of solar cooling desired during times when solar heat is not available

12. Supplements solar collection system as needed to maintain sufficient systems tank temperature to meet the cooling load requirements

13. Permits full flow of hot water to the generator or bypass flow back to the systems tank

14. Circulates water from the chiller unit to the cooling tower

15. Circulates water from main storage tank, through the collector bank and back to the systems tank

16. Provides automatic changeover from heating to cooling on command from the thermostat

17. Circulates water from the systems tank through a heat exchanger in the domestic water heater

8. Select components to be piped in a typical plumbing run for the PWF 36-100 system by placing an "X" in the appropriate blank.

_____a. Main storage tank

_____b. Fan-coil unit

_____c. Fan-coil unit condenser

_____d. Solution pump

_____e. Evaporative cooling tower

_____f. Domestic hotwater heater

_____g. Auxiliary boiler pump

_____h. Collectors to storage tank

_____i. Collectors to systems tank

_____j. By-pass valve circuit

_____k. Collectors to expansion joints

_____l. Expansion joints to manifold

_____m. Heat-cool valve circuit

_____n. Boiler relief valve

_____o. Fan-coil condensate drain

_____p. Domestic hotwater relief valve vent

_____q. Cooling tower makeup water

9. Match the hydronic coil components on the left to their correct function.

_____a. Chilled water by-pass valve	1. Controlled by the room thermostat to provide fan motor operation in the cooling mode
_____b. Fan delay control	
_____c. Chilled water aquastat	
_____d. Fan relay	2. Controls operation of the chilled water by-pass valve

3. Used to bypass part of the fan-coil when temperature of the chilled water supplied to the coil reaches 49°F

4. Turns the fan motor on when the coil temperature reaches approximately 130°F and turns if off at approximately 100°F

10. Select the components used in the PWF 36-100 heating mode by placing an "X" in the appropriate blank.

_____a. Fan-coil unit

_____b. Heat-cool valve

_____c. Domestic heater circulator pump

_____d. Chilled water pump

_____e. Solution control valve

_____f. Low temperature bypass valve

_____g. Fan coil tank

_____h. Fan coil unit circulator pump

_____i. Collector pump

_____j. Systems tank

_____k. Solution pump

_____l. Solar collectors

_____m. Auxiliary boiler

_____n. Boiler circulator pump

11. Match the WF-36 switches and controls on the left to their correct function by placing an "X" in the appropriate blank.

_____a. Solution bypass valve

_____b. Evaporator low temp limit switch

_____c. High temp switch

_____d. Solution bypass switch

1. Energizes the solenoid coil on the solution bypass valve when the evaporator coil temperature drops to 36°F ± 1°F

2. Interrupts hot water flow and condensing water flow through the unit if the coil temperature goes down to approximately 33°F ± 1°F

3. Will open to stop the flow of hot water to the generator, stop the chilled water pump and shut off the chiller solution pump if the condenser surface temperature reaches 120°F ± 6°F

4. Functions to bypass weak solution away from the absorber coils to prevent flashing of refrigerant

12. Discuss the location and purpose of thermometer wells on the WF-36 chiller.

a. Purpose--______________________________________

____

____

____

b. Location--____

____

____

13. Discuss the characteristics of wiring diagrams and schematic diagrams.

a. Wiring diagrams--__________________________________

____

____

b. Schematic diagrams--_______________________________

____

____

14. Select specifications listed on the WF-36 specification sheet.

_____a. Physical data, approximates

_____b. Service connections

_____c. Circulator pump size in horsepower

_____d. Collector type

_____e. Cooling tower selection data

_____f. Condensing water data

_____g. Expansion joint sizes

_____h. Chilled water data

_____i. Energy requirements

_____j. Chiller operation cycle

_____k. Design delivery capacity, tons

_____l. Design delivery capacity, Btu/Day

_____m. Design delivery capacity, Btu/h

15. List seven components used in the Yazaki solar absorption system cooling mode.

a. ______________________________________

b. ______________________________________

c. ______________________________________

d. ______________________________________

e. ______________________________________

f. ______________________________________

g. ______________________________________

16. List five components used in the Yazaki solar absorption system heating mode.

a. ______________________________________

b. ______________________________________

c. ______________________________________

d. ______________________________________

e. ______________________________________

17. Match sequence of operation of an absorption system on the right to their correct appplication.

a. Cooling

_____1)

_____2)

_____3)

b. Heating

_____1)

a. Chilled water is then pumped through the fan-coil unit to cool air from the conditioned space

b. Solar heated water is supplied to the generator of the solar chiller

c. Solar heated water is supplied directly to the fan-coil unit

d. The hot water activates the generator to produce an absorption refrigeration cycle and chilled water

18. List in order the four basic cycle stages in a water lithium bromide absorption chiller.

a. ____

b. ____

c. ____

d. ____

19. Match the four basic sequence stages of a water/lithium bromide absorption chiller to their correct definition.

_____a. First stage

_____b. Second stage

_____c. Third stage

_____d. Fourth stage

1. The "evaporation" stage vaporizes the water condensed in the second stage in a vacuum and produces chilled water

2. At the "condensation" stage, the water vapor is condensed by cooling water

3. Solar heated water heats the lithium bromide solution to boiling point to produce a thick solution of lithium bromide and water vapor

4. At the "absorption" stage the thick lithium bromide solution obtained in the first stage is sprayed over the cooling water coil, absorbing the water vapor and producing chilled water in the coil-unit

20. Demonstrate the ability to:

a. Identify piping runs used in a solar fired absorption heat/cool system in the cooling mode.

b. Identify piping circuits and components used in the heating mode of a solar fired absorption heat/cool system.

c. Identify piping circuits and components used in the cooling mode of an absorption heat/cool system with auxiliary boiler "on".

d. Identify piping circuits involved in the solar heat mode of an absorption heat/cool system with backup boiler "off".

e. Assemble a PWF 36-100 package unit and locate support components.

f. Install piping circuits for an absorption heat/cool package system with drain back collector loop.

g. Install piping circuits for an absorption heat/cool system storage tank.

h. Install an evaporative cooling tower for an absorption heat/cool system.

i. Install a fan-coil unit for a solar absorption heat/cool system.

j. Install gas piping circuit for the back-up boiler of an absorption heat/cool system.

k. Install solar hotwater heater piping circuit.

l. Install power and control circuits for a solar absorption heat/cool system.

m. Start-up and performance check an absorption heat/cool system.

SOLAR ABSORPTION SYSTEMS
UNIT III

ANSWERS TO TEST

1. a. 5
b. 8
c. 1
d. 7
e. 9
f. 4
g. 3
h. 6
i. 2

2. a. ARKLA Industries
b. Yazaki Corporation

3. a. water
b. lithium bromide

4. a. 7
b. 5
c. 3
d. 1
e. 13
f. 2
g. 11
h. 12
i. 4
j. 10
k. 9
l. 6
m. 8
n. 17
o. 14
p. 13
q. 16
r. 15
s. 18

5. a. When grouped, must be capable of supplying hot water in the 170°F - 205°F range at the required flow rate

b. Must be able to operate in a drain back system

6. a, c, d, h

7. a. 3
b. 5
c. 6
d. 4
e. 1
f. 2
g. 7
h. 8
i. 10
j. 16
k. 14
l. 12
m. 11
n. 9
o. 15
p. 17
q. 13

8. a, c, f, h, i, k, l, n, o, p, q

9. a. 3

b. 4

c. 2

d. 1

10. a, b, c, g, h, i, j, l, m, n

11. a. 4

b. 2

c. 3

d. 1

12. a. Should include--To provide location and means of checking operational temperatures of the chiller units

b. Should include--Located at the inlet and outlet connections of the hot, chilled and condensing water outlets

13. a. Should include--Identifies connection points for fired installation of power supply wiring and 24 volt control circuits

b. Should include--Makes it easy to identify individual circuit loads and controls

14. a, b, e, f, h, i, j, m

15. Any seven of the following in any order:

1) Flat plate collectors

2) Storage tank

3) Back-up boiler

4) Hot water fired boiler

5) Fan-coil unit

6) Cooling tower

7) Collector loop circulator pump

8) Boiler pump

9) Fan-coil pump

10) Cooling tower pump

16. Any five of the following in any order:

1) Flat plate collectors

2) Storage tank

3) Back-up boiler

4) Fan-coil unit

5) Collector loop pump

6) Boiler pump

17. a. Cooling

1) b

2) d

3) a

b. Heating

1) c

18. a. Regeneration

b. Condensation

c. Evaporation

d. Absorption

19. a. 3

b. 2

c. 1

d. 4

20. Performance skills evaluated to the satisfaction of the instructor.